

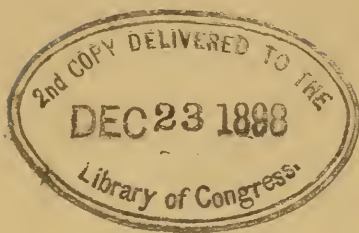
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*FOR THE USE OF TECHNICAL SCHOOLS,
MANUAL-TRAINING SCHOOLS,
AND AMATEURS.*

IN THREE PARTS.

PART I. THE SPEED-LATHE.

BY
ALFRED G. COMPTON
AND
JAMES H. DE GROODT.

FIRST EDITION.

FIRST THOUSAND.

NEW YORK:
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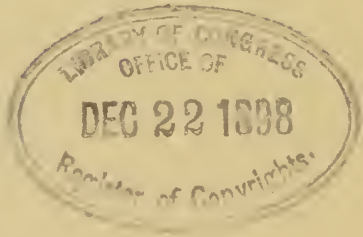
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PREFACE.

THE lessons in lathe-work and planer-work here set forth represent pretty closely the course of instruction in this subject which an experience of thirteen years has developed in the College of the City of New York. The mechanical course in this college is a five years' course (including a preparatory or sub-freshman year), collegiate in character, like the other courses, and leading to the degree of Bachelor of Sciences. To the workshop and the laboratory is given an average of four hours a week throughout the five years. These lessons represent the work of the sophomore year, four hours a week, and the junior year, three hours a week, or, deducting holidays, about two hundred and thirty-eight hours in all. The greater part of the exercises, except those expressly described as extra tasks given for the purpose of imparting facility, are performed by all the students of the class,* though a few are divided among them in such a way that some perform one

* In Part I, exercises 14, 15, and 36 to 39 are such.

exercise or one part of an exercise, while others are performing another, all the operations, however, being, in such cases, watched and understood by all. The lessons represent, therefore, about what a student who has had good training in mathematics and drawing and in elementary wood-work and metal-work may be expected to do in the time named.

While these lessons are not intended to dispense with the watchful eye and the helpful hand of an instructor, they are designed to furnish to the student such explicit directions that he shall be able, in most cases, to do the work well if he will follow the directions exactly. The authors believe that the mechanical skill alone which a course of manual training imparts is only a part, and not even the most valuable part, of the training which the workshop and laboratory can give: the power of intelligent reading and of accurate and orderly description is equally important, and so is the power of foreseeing the difficulties that will arise in the course of a given operation and of devising means to evade or overcome them. These powers it is hoped that these lessons may help to impart.

THE COLLEGE OF THE CITY OF NEW YORK,
August 8th, 1898.

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ADVANCED METAL-WORK.

PART I.

THE SPEED-LATHE.

LESSON I.

PARTS OF THE LATHE. CARE AND MANAGEMENT OF THE LATHE AND TOOLS.

As you stand facing the lathe you have at the left (Fig. 1) the head-stock *A*, with the belt running on the cone, *B*, giving motion to the live-spindle *C*. *DD* are bearings and **Parts of lathe.** journals of the live-spindle, and *F* is the spur-centre. At your right is the tail-stock *G*, with the dead-spindle *H*, the tail-pin *I*, and the handle *J* of the spindle-screw, which moves the dead-spindle in or out. Between the head-stock and the tail-stock is the hand-rest, on which the cutting-tool rests. All these parts are fastened to the shears *L*, which are the straight and parallel guides, on the bed *M*. To these shears the head-stock is clamped by bolts

O, holding it fixed, while the tail-stock and hand-rest are fastened by clamps *P*, which can be easily

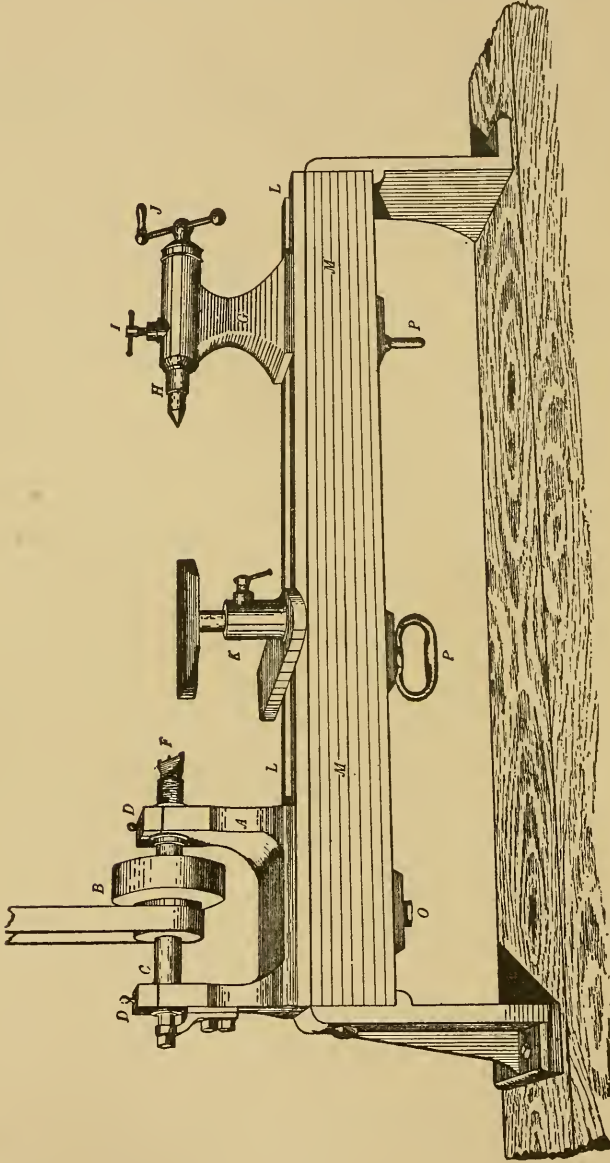


FIG. 1.

loosened, allowing these parts to be placed at pleasure.

All parts of the lathe, but especially the bright parts, should be wiped off clean after using. Tools, pieces of metal and work should never be laid on the shears, lest these be thus bruised or nicked.

The belt must be kept straight and free from twist to insure its running well. To this end, at the close of the day's work **Care of the** it should be carefully folded and **belt.**

wrapped around the head-stock in such a way as to keep it flat. When in use it is found to run best with the smooth side towards the face of the cone or pulley. The smooth side is the side on which the hair was. In the process of tanning the skin and removing the hair, and thus converting the skin into leather, the oily substance at the root of each hair is destroyed, leaving in this smooth-finished side numberless little cavities or holes. If this side, which is also the weaker, is turned toward the face of the cone or pulley, as at *a*, Fig. 2, these pores or cracks are closed; thus a better contact is insured, with greater friction, the belt is more easily curved around a small pulley and made to touch its whole width, and it will transmit more power before slipping. With the rough or flesh side of the belt towards the pulley, as at *b*, the reverse is true: the cracks tend to open more and more, weakening the belt and finally breaking it.

Above the lathe is a counter-shaft which receives

motion from the main shaft. On the main shaft is fixed a pulley, and on the counter-shaft are two, each of half the width of this one. Examining

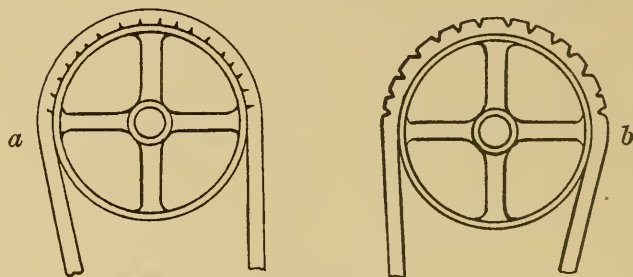


FIG. 2.

either the counter-shaft overhead or a similar one mounted as a model in a convenient place, you will find that one of the two pulleys is firmly attached to the counter-shaft by a set-screw, while the other is loose, so that if the belt from the main shaft to the counter-shaft is on the fast or tight pulley it will drive the counter-shaft, while if it is on the loose pulley it will leave the counter-shaft at rest.

Shafts and pulleys.

Notice the cones and the small pulleys on your lathe and counter-shaft and you will find them "crowned," or the surfaces high in the middle. When a pulley revolves the centrifugal force tends to throw out anything that is on it, as you have already observed in oiling your machine. Thus the belt also as it revolves creeps up from a small diameter to a larger one. When the surface of a pulley or cone is made curved or high in the mid-

dle, each half of the belt tends to climb towards the high side, just as two belts running side by side would, thus keeping the belt at the middle of the pulley. Pulleys used for shifting belts (generally the driving-pulleys) have flat faces, while those used as driven pulleys, such as the "cones" of lathes, have crowned or curved faces. The "crowning" of pulleys is theoretically wrong, since it prevents the belt from pressing equally on all parts of the surface, and it would not be necessary if the shaft could be kept perfectly in line and the belts were perfect.

Both centres are frequently removed from the spindles. The live-spindle often has a hole bored through its whole length, and in this case the centre is easily removed by passing through the hole a piece of round iron and driving the centre out

Exercise 1.
Removing
and replac-
ing centres.

by gentle blows of the hammer. The dead-centre or tail-centre is sometimes removed by the action of the tail-screw. When the screw is turned so as to draw back the spindle in which the dead-centre is inserted, the point of the screw comes

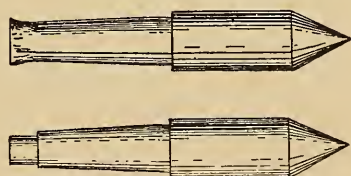


FIG. 3.

in contact with the base of the centre and pushes it out. Both in this case and in the last, the base of the centre being subjected to frequent

pressure or blows, it is likely to become upset or enlarged. It should therefore be turned for a small part of its length, not exceeding $\frac{1}{4}$ in. at the end, a little smaller, so that if it is thus enlarged it may not fit too tight and thus score or scratch the inside of the spindle.

The dead-centre has in some cases a hole drilled through it perpendicular to its axis into which a steel pin can be inserted. It is then easily removed by turning it by means of the pin. When no special provision is made for removing the centre, whether live or dead, a copper hammer (not a steel one) should be held under it, and then with a hammer and drift or dull chisel it should be jarred loose by gentle taps against its shoulder.

There is but one correct way of inserting a centre in its spindle. First see that the centre and the hole in the spindle are perfectly clean, and if there are any nicks or scratches, even slight ones, remove them with an old smooth file. Put the centre into the hole and push and turn it in its place, but never drive it. Driving the centre is apt to make it hold so tight that blows are required to remove it, and both actions are likely to injure the lathe. A chalk-line drawn along the whole length of the centre will generally keep it from slipping; if it does not the fit is imperfect, and it should be refitted as

will be explained in Lesson VII on Engine-lathe Work.

To prevent injury to the dead-spindle it should not be allowed to project beyond the tail-stock farther than is necessary to allow of getting at the work easily. To set the tail-stock properly, screw the spindle as far back as it will go, and move the stock up till the dead-centre touches the work as you hold it between the centres with your left hand; now screw the spindle out, and the centre, pressing against the work, will push the stock back along the shears; let the stock go back thus till you have room enough to allow of taking the work out and putting it back easily, and fasten the stock with the clamp-screw.

Exercise 2.
Setting the
tail-stock.

The spindle slides in a smooth hole in the tail-stock and is kept from turning by means of a

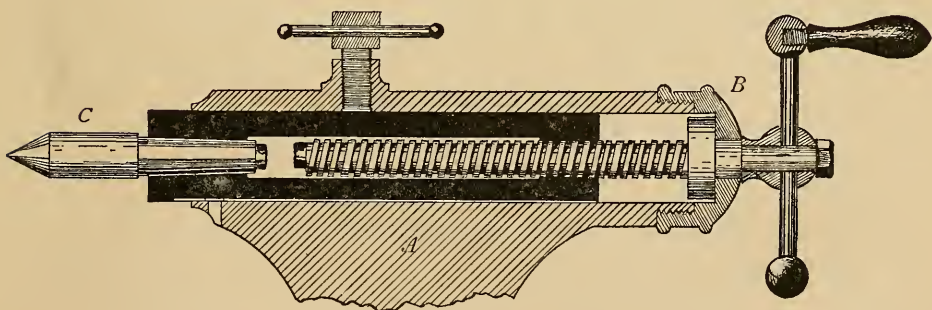


FIG. 4.

spline or groove cut in one side, into which a feather or pin is fitted. To move this spindle

there is a screw which revolves in the stock *A*. It is supported and held in place by a bearing *B*, screwed fast to the end of the tail-stock. This screw turns in a corresponding brass nut *C* in one end of the spindle, which is made hollow and has a conical or taper hole in one end for the insertion of the dead-centre, and a long cylindrical hole in the other end for the admission of the screw.

The thread on the screw may be either right- or left-handed, the latter being preferable, however, for the reason that it is natural for the majority of workmen to turn the screw towards the right to move the spindle forward; as the screw turns it is evident that if it is a left-handed one the nut must move forward on the screw, whereas if it were right-handed the reverse would happen, the spindle would be drawn backward and the work loosened between centres. In some lathes, however, the right-handed screw is used, perhaps because of a slight difference in cost. Besides being left-handed the screw should have a double thread, which would move the centre twice as far for the same number of turns of the handle as a single thread would, without materially weakening the screw. As the standard angle of a *V* thread is 60 degrees and the depth of an ordinary square one is about equal to its width, it is evident that if the pitch is a coarse one the thread will be correspondingly deep. For example, if it is desired to

cut a thread that will move the spindle $\frac{1}{4}$ of an inch for every turn of the handle, and the diameter of the screw is only half an inch, a single thread having a pitch of $\frac{1}{4}$ in. will reduce the diameter of the core or bottom of the thread to $\frac{1}{4}$

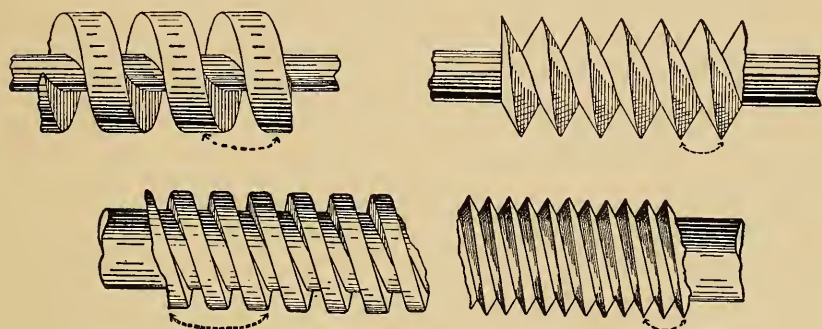


FIG. 5.

of an inch, which is too small for practical use, whereas with a double thread of the same pitch the strength is that of a thread of $\frac{1}{8}$ inch pitch, as shown in the figure. The workman must make many turns of the screw during the day, and a saving of one half the number is not to be despised.

LESSON II.

STARTING AND STOPPING. CALCULATING THE SPEED.

IN starting the lathe the belt should be run gradually, not suddenly, from the loose to the tight pulley. If it is shifted too quickly it will slip on the tight pulley before the lathe gets into motion, or, which is more troublesome, will run off the pulley altogether.

Exercise 3.
Starting.

To increase the speed of the live-spindle the lathe-belt is shifted from a smaller to a larger step on the counter-shaft, which causes the belt to run faster, and from a larger to a smaller step on the lathe-cone. The latter change of course must be made first. To lessen the speed the opposite changes must be made. Practise the two changes successively.

Exercise 4.
Shifting the belt.

First, to increase the speed: Holding the left hand against the left edge of the belt about one foot above the head-stock, push the belt with the right hand so as to guide it off from the large step of the cone to the small one. (The holding of the left hand as directed has for its object to prevent

the belt from being pushed too far to the left, which in the case of the engine-lathe might cause it to be caught in the gear-wheel and injured. Though this danger does not exist in the case of the speed-lathe, it is important to form the correct habit in the beginning.) The belt is now slack, being on the small step both of the counter-shaft and of the lathe-cone. It is now to be shifted to the larger step of the cone on the counter-shaft. To accomplish this pull the belt forward with the palm of the left hand, stretching it a little. Removing this hand quickly, you will allow the belt to spring back by its elasticity, and at this moment, giving it a push or throw with the right hand, you will guide it on to the larger step on the cone of the counter-shaft. It will require some practice to get facility in this movement. The reverse operation, first on the counter-shaft and then on the cone, will reduce the speed.

Measure the diameters, first, of the driving-pulley of the engine and the driven pulley on the main shaft; second, of the driving-pulley on the main shaft and the driven pulley on the counter-shaft; third, of the several steps of the driving-cone on the counter-shaft and the corresponding steps on the lathe-cone. Then, counting the number of revolutions per minute of the engine, either by the eye or by the ear, or by a so-called tachometer or

Exercise 5.
Calculating
the speed.

speed-counter, determine: first, the speed of the shaft; second, that of the counter-shaft; third, that of the spindle with the belt on each of the several steps of the cones. After your calculations are completed you may verify them by taking the speeds of the shaft, counter-shaft, and cone with the tachometer.

The measured and the calculated results should nearly agree. They will not agree exactly, first, because of small errors in the measurements of the several diameters, and second, because the belts always slip to some extent on the pulleys, making the driven pulley run less rapidly than the calculation would indicate.

In order to be perfectly accurate in calculating speeds the diameter of a pulley should always be measured so as to include one half the thickness of the belt which is around the pulley or cone. The diameter of the pulley plus one thickness of the belt will give the correct result. Some fast-running machines, such as circular saws, emery-wheels, engine-governors, etc., etc., have the speed at which they should be run stamped on the machine in plain sight. Now, knowing the desired speed of the machine and the speed of the engine, it is very easy to calculate the sizes of the pulleys needed. When the thickness of the belt is added to each pulley, as, for instance, $\frac{1}{4}$ " to the 8" pulley on the main shaft and the same ($\frac{1}{4}$ ") to the pulley

on the counter-shaft, the proportion is changed : the driving-pulley would now be $8\frac{1}{4}$ " instead of 8", and the driven pulley $4\frac{1}{4}$ " instead of 4". One pulley would now be $\frac{1\frac{7}{8}}{\frac{1}{3}\frac{7}{8}}$ of the other, and not $\frac{1}{2}$, or $\frac{1\frac{7}{8}}{\frac{1}{3}\frac{7}{8}}$, which would make on a machine at a speed of 500 revolutions, a difference of about 9 revolutions per minute.

LESSON III.

CENTRING AND MOUNTING WORK. PLAIN TURNING
WITH THE GOUGE.

Cut off a piece of white pine 8" long and $2\frac{1}{4}$ " square. Find the centre of each end by the intersection of two diagonals, and mark the centres with a centre-punch or with the lathe-centre, using a copper hammer. From this piece turn a cylinder 2" in diameter by the eye.

Exercise 6.
Centring and
mounting.

You should have in the drawer of your lathe five tools: two gouges, large and small; two chisels, large and small; and a square-nose or parting tool. Place these tools on your lathe-bench in front of you, at right angles to the length of the lathe, with their handles under the bed of the lathe and their cutting edges far enough out to be seen as you stand at the lathe, so that you can always pick up the right tool without loss of time or risk of cutting your hand.

To mount the work, feed the tail-spindle back by turning the screw as far as it will go; hold the work in the left hand, with one end held up to the

live-centre, and move the tail-stock up to it till the tail-centre enters the centre at the other end of the piece and holds it loosely. Now, before fastening the tail-stock, turn the centre-screw so as to push the centre forward against the work, thus pushing the tail-stock back, till there is room enough to allow of removing the work by screwing the centre back without moving the stock, and not much more. If the spindle projects further than is necessary it will bend or "spring," and cause the work to chatter and turn rough. Clamp the tail-stock fast.

The gouge and chisel are very much like the corresponding carpenter's tools except in length and in the form of their cutting edges. The **Turning-** wood-turner's tools and their handles **tools.** are longer than those of the carpenter's to allow the workmen to stand away from the dust and shavings made by the lathe. The wood-turner's tools are bevelled differently from those of the carpenter: the bevel of the gouge is on the convex side (Fig. 6, *A*), while that of the carpenter's paring-gouge is on the concave side (Fig. 6, *B*), and the turner's chisel is bevelled on both sides. The edge also is differently shaped: that of the carpenter's gouge is in a plane perpendicular to the length, while that of the turner's gouge is curved out of this plane, so that the latter is analogous to the jack-plane and cuts a groove or trough, while

the former is like the smoothing-plane and would cut a more nearly plane surface. The cutting edge

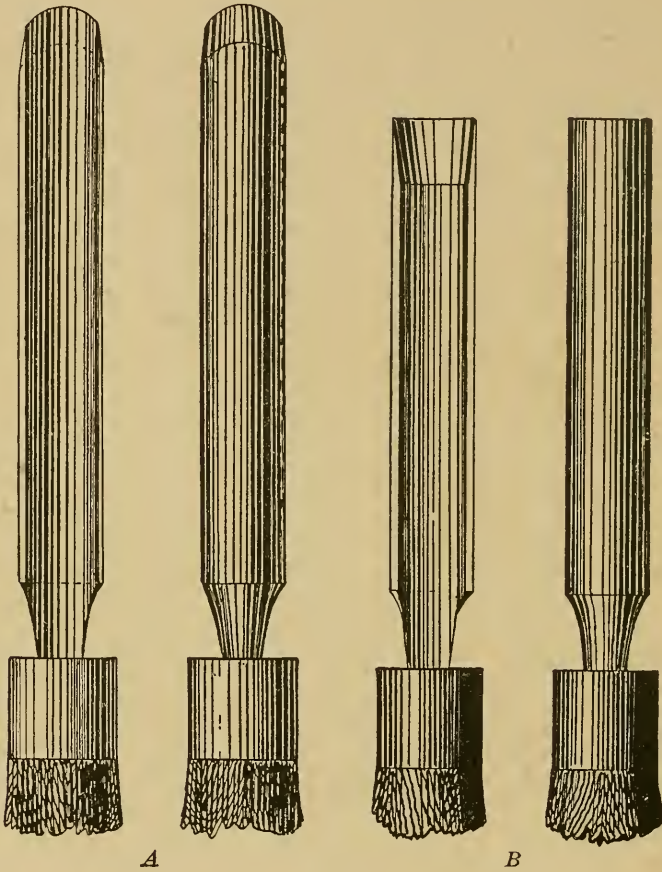


FIG. 6.

of the turner's chisel is inclined to the axis of the tool at an angle of about 60° instead of being perpendicular to it, as in the carpenter's chisel. The size of the cutting angle in either of the tools depends on the kind of wood to be worked, and may be about the same as in the carpenter's tools.

The piece of work being mounted between the centres, see that the centre is oiled and that there is no side-play between the centres.

At the same time the piece must be free to turn easily. Any excess of pressure will cause undue friction on the shoulders of the journal and face of the bearings, with heating

Exercise 7.
Plain turning.

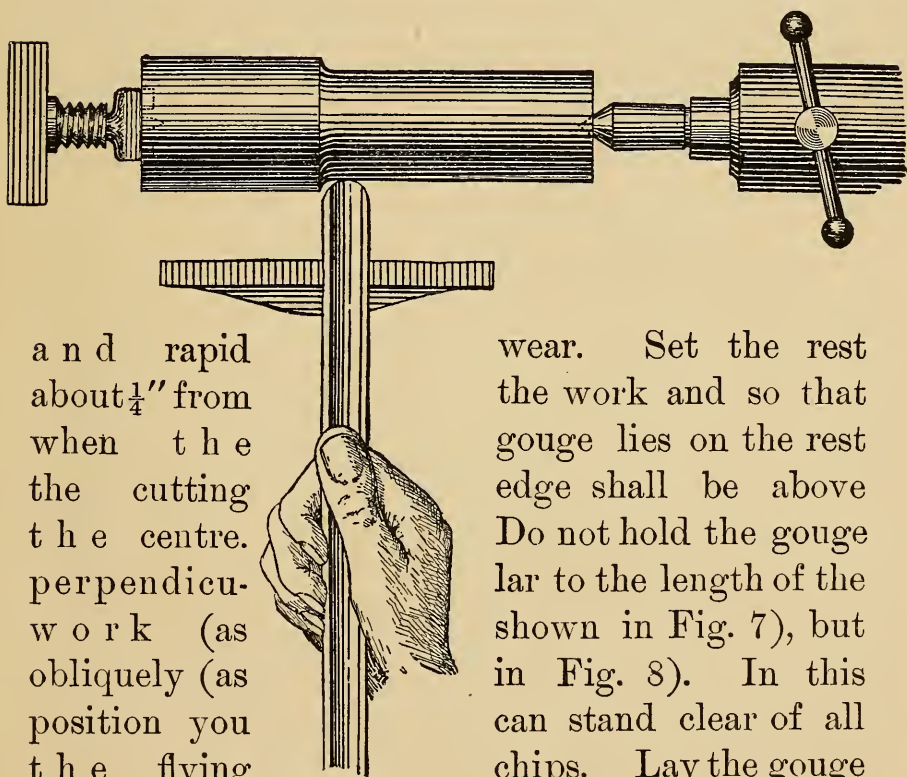


FIG. 7.

and rapid about $\frac{1}{4}$ " from when the the cutting the centre. perpendicular work (as obliquely (as position you the flying with its edge

swung well over towards the right, the concavity facing towards the left. Bring the cutting edge carefully against the piece near the right-hand end and move it along steadily from right to

wear. Set the rest the work and so that gouge lies on the rest edge shall be above Do not hold the gouge lar to the length of the shown in Fig. 7), but in Fig. 8). In this can stand clear of all chips. Lay the gouge on the rest, the handle

left, taking off about the same quantity all along the length of the piece. Carry the gouge back to the right-hand end and repeat the operation.

You can cut from left to right in the same way, swinging the handle towards the left, keeping the

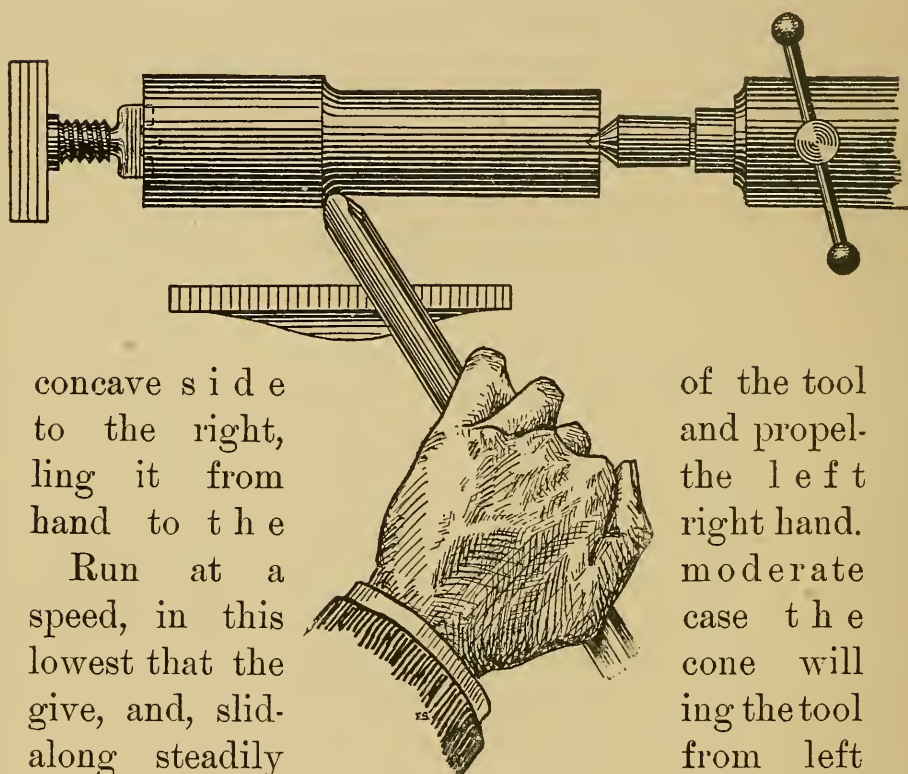


FIG. 8.

concave side to the right, ling it from hand to the

Run at a speed, in this lowest that the give, and, slid-along steadily to right, take

cuts till the corners are all turned off and the piece is approximately cylindrical.

The first cut must be made cautiously, as, while the piece is square or nearly so, there is danger, if you cut too deep, of having the tool caught by the work and perhaps jerked out of your hand.

of the tool and propel the left right hand. moderate case the cone will ing the tool from left successive

In turning large, heavy work, and any work while taking off the corners, it is well to hold the handle of the gouge firmly against your side. You must stop occasionally and test the work, and take up any play which may have resulted from the wearing away or compression of the wood at the centres. If this last point is not attended to the work will get loose in the centres and will not be turned true, or it may even fall out. After you have become a little accustomed to the handling of the tool you should keep your eye on the work rather than on the cutting edge of the tool—just as you do in chipping metal or chiselling wood.

As in forge-work, so in wood-turning you must learn to work by eye measurement. Turn the piece down to as near 2" as you can by eye before using the calipers. Then face off the end with the chisel, holding it flat on the rest, perpendicular to the axis of the piece, and with the long side towards the piece. Push the chisel down towards the centre, cutting off enough to make the work run true. We now call the work approximately true and balanced, and it will now be safe to change to a higher speed before finishing.

A point of the utmost importance in turning is to use only properly ground and sharpened tools. It will be worth while to try for once to work with improperly ground tools, so as to impress this thoroughly on your mind. After such experiments

you will not be likely to work with bad tools in the mistaken idea that in sharpening them you are losing time.

When your work is true and parallel finish it smooth with the chisel. The chisel, like the smooth-Chisel. ing-plane in carpentry and the flatter in forge-work, is only a finishing-tool. All work

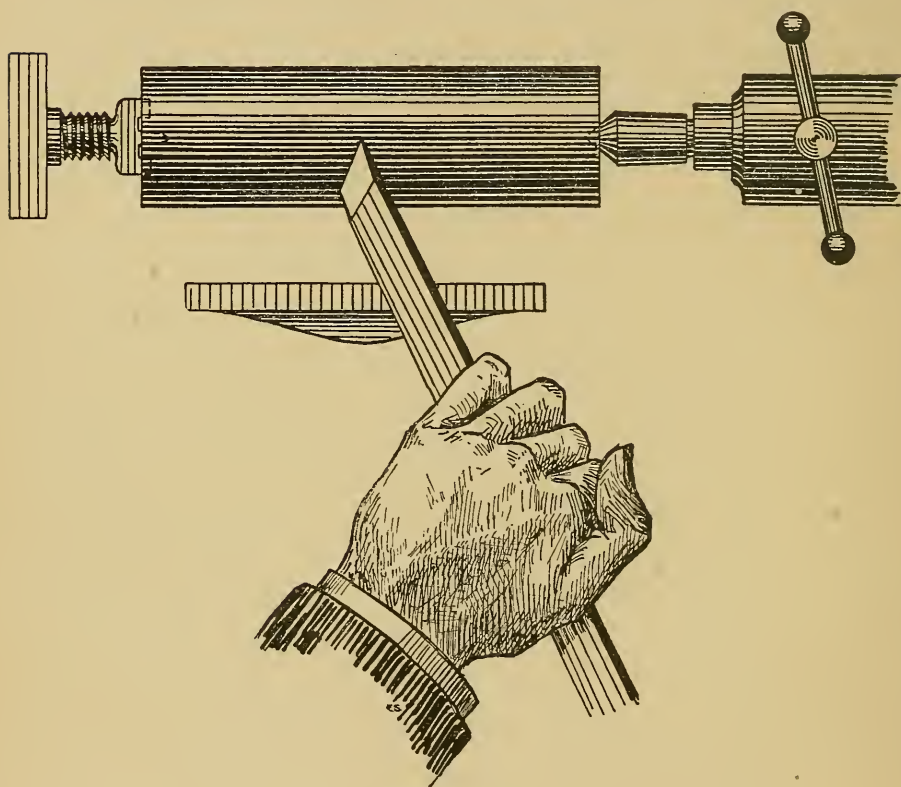


FIG. 9.

should be prepared and brought near to a finish with the gouge, after which the chisel, if in proper condition and properly used, will finish the work better than you can do it with sandpaper. The

chisel is held in about the same position as the gouge, with the whole of the bevelled surface bearing on the work, as in Fig. 9. In this position it will cut and polish at the same time. The short side should lie on the rest, the long side or acute angle being turned towards the right, and the handle swung horizontally to the right. All these points are shown in the figure. Give careful attention to them, for if the chisel is held thus, and firmly, it will not slip and dig into the work.

Practise with these two tools till you are able to turn very near to size, smooth and parallel, with the eye alone, without the calipers.

From the pieces of work left in the last exercises turn a taper plug to dimensions fixed in a sketch in advance, say 8" long, and 2" and 1" in diameter at the ends.

Exercise 8.
Taper turning.

First lay the gouge with its edge on the tee of the rest, with the handle in the right hand swung well over towards the left, and the concavity facing towards the right.

Bring the cutting edge carefully against the piece at *A*, Fig. 10, about 1" from the tail-centre end, and move it along steadily from left to right. Carry the gouge back again and take another cut; repeat the operation till the piece of work for about $\frac{1}{2}$ " of its length is turned to the smallest diameter. Now in the same manner turn the taper straight and true, commencing first at *B*, then *C*,

D, etc., taking successive cuts downwards from the larger to the smaller diameter. Finish the

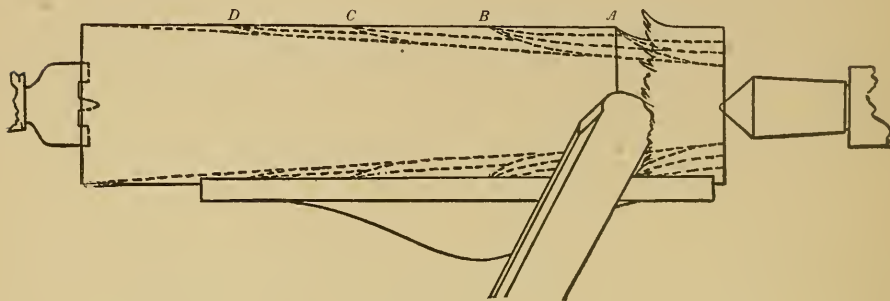


FIG. 10.

surface smooth with the chisel, as in the last exercise.

LESSON IV.

TURNING CONCAVE AND CONVEX SURFACES WITH
THE CHISEL.

CUT off a piece of pine or white wood $8'' \times 2\frac{1}{4}'' \times 2\frac{1}{4}''$ and turn to the shape and size indicated in the figure.

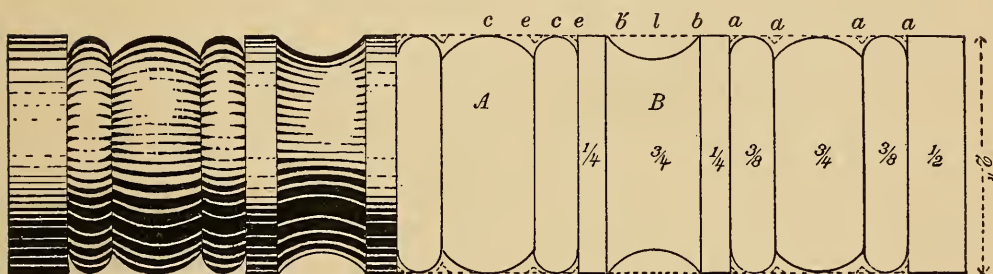


FIG. 11.

First turn to a true cylinder. Mark off the spaces with a lead-pencil while the piece is at rest, then start the lathe and mark with the acute corner of the chisel, inserting the point well into the work at the junctions of the convex surfaces or beads and ribs *a, a*. A very light cut must be made at *b, b*, the boundaries of the concave surfaces, as these are not to be cut down at the ends.

Exercise 9.
Straight and curved surfaces to pattern.

Turn the beads, ribs, and fillets with the chisel

alone. (The gouge is not to be used, as the object of the lesson is to attain skill in the use of the chisel. After this is accomplished it will be found that better work can be done than with the gouge and more quickly.) In doing this you will appreciate the advantage of having learned to work with your eye fixed on the surface to be cut rather than on the cutting-tool. The convex surfaces and the concave surfaces will have to be treated differently.

To cut the convex surface or bead or rib, place the chisel nearly flat on the tee of the rest, as

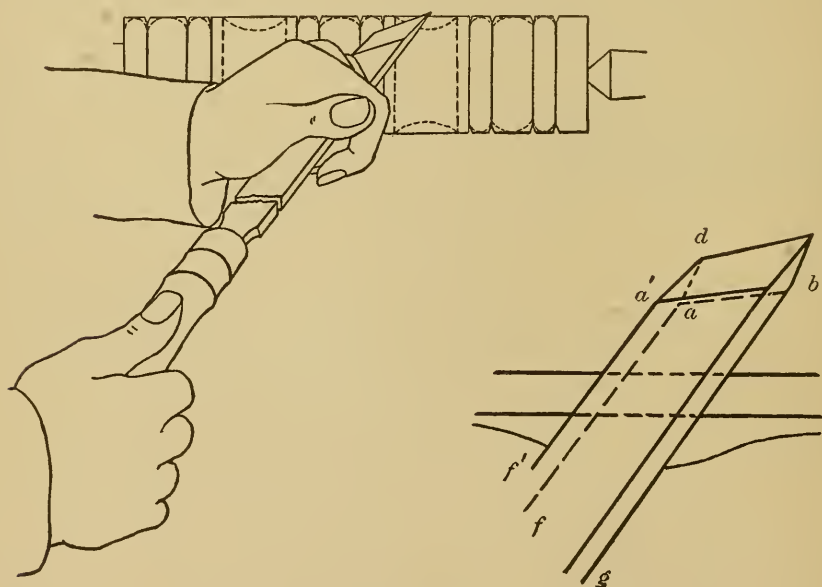


FIG. 12.

in Fig. 12, the handle swung round to the *left* and the long edge *bg* a little raised, so that the tool rests

on the short edge *af*. In this position advance it till the heel *d* just touches the work at *c*, the middle of the bead *A*, Fig. 11. Turn the chisel gradually up on the short edge *af* until its plane or face *fb* is nearly vertical, and at the same time swing the handle to the right and upward, which

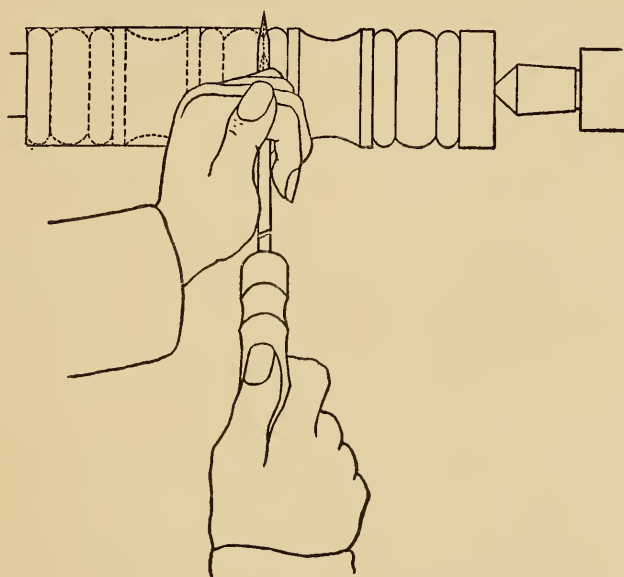


FIG. 13.

will cause the cutting edge to move along the work to the left and downward, as shown in Fig. 13.

The other half *ce* of the bead is cut by similar but reverse motions. That is, you will stand in the same position, but with the handle of the tool (in the same hand) swung round to the right instead of the left (Fig. 14). The long edge *bg*

will be to the left and slightly raised, while the chisel lies nearly but not quite flat, resting on the short edge *a'f'*, Fig. 12. Then turn the chisel gradually up round this edge as before, swinging the handle at the same time towards the left and upward, making the heel of the tool move toward the right and downward, till it takes again the position shown in Fig. 13.

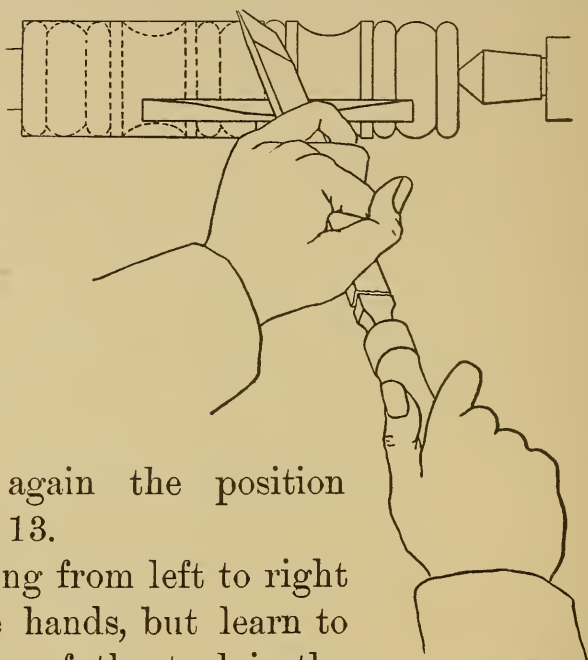


FIG. 14.

While cutting from left to right do not change hands, but learn to hold the handle of the tool in the right hand and the blade always in the left. The importance of this will be appreciated in underhand cutting later. It is obvious that while holding the blade in your right hand that hand is not free to attend to the dead-centre or to pick up a pair of calipers, or the rule, or the model, without moving the tool from the rest, in doing which it is apt to become nicked.

To cut the hollow *B*, Fig. 11, again use the chisel alone, but begin near *b*, and cut the part *bl*

then at b' to cut $b'l$. For the first, begin with the chisel resting on the short edge or right-hand corner af , the longitudinal plane through the cutting edge nearly vertical, as in Fig. 15,

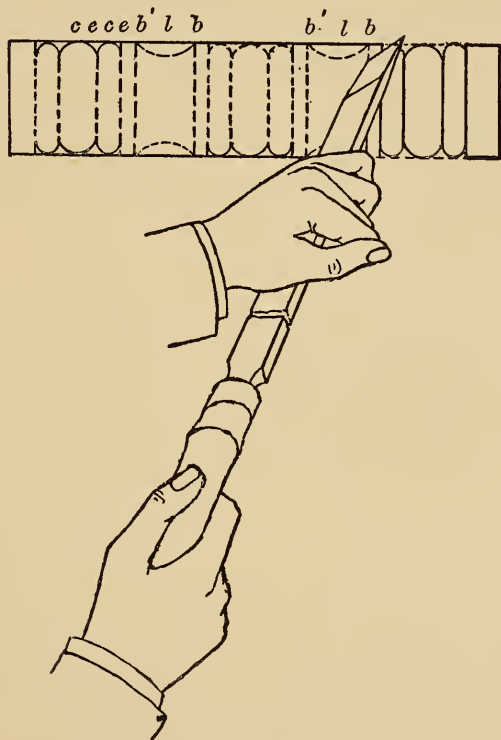


FIG. 15.

but inclined over a little towards the right, and the handle swung round towards the left. As the tool cuts, turn the cutting edge more and more from the vertical towards the right, and swing the handle toward the right and up, so that by the time the point l is reached, the handle of the chisel shall be nearly perpendicular

to the work, as in Fig. 16. In cutting $b'l$ the plane of the edge of the chisel inclines increasingly towards the left, and the handle, which is swung far to the right in the beginning, is

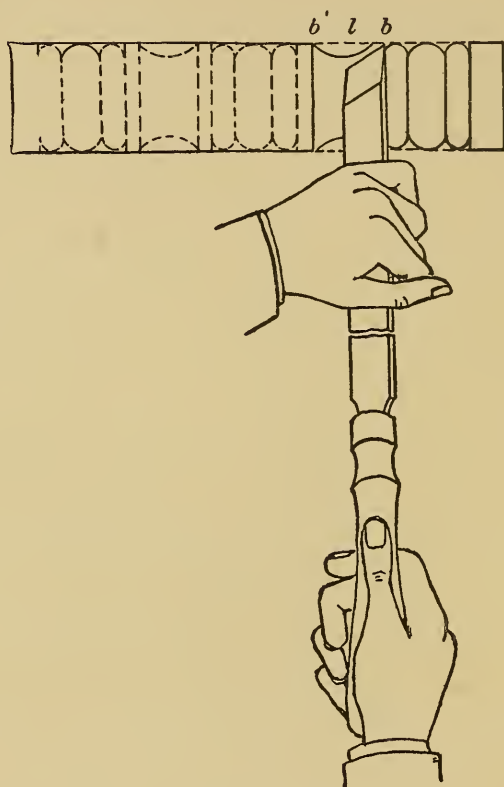


FIG. 16.

brought more and more nearly perpendicular, being raised a little at the same time. In finishing up remove the ridge that will form in the middle by going over the surfaces lightly with the middle part of the edge (and not with the heel) passing a little beyond the centre of the fillet,

Care must be taken to have the two quadrants of the bead and the two half curves of the fillet exactly alike and symmetrical. Your ability to do good work on this exercise depends upon having sharp and properly ground tools. The heel does the cutting, while the surface following guides and polishes.

If you can succeed in catching these motions you will be able to take off the wood with a cutting rather than a scraping motion and will leave the surface smooth.

In turning the curved surfaces of the bead and the hollow the heel or obtuse corner of the chisel is the cutting one, while in turning down a side face it is the acute angle that is used. tilted a

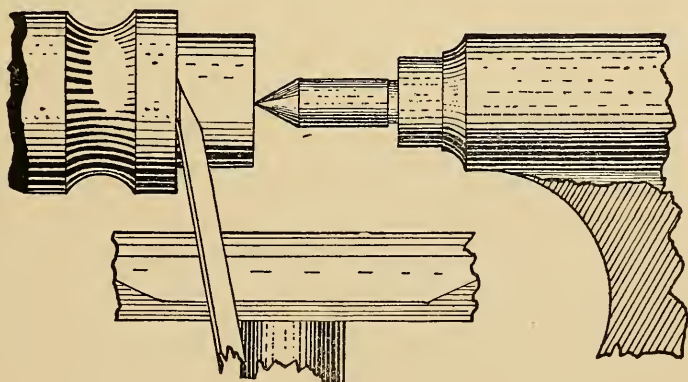


FIG. 17.

little as shown in Fig. 17. This angle is almost always used for cutting off and cutting down shoulders; but if used for finishing a straight or

square surface it is apt to make the surface of the work wavy.

For practice with the tools, and to train the eye and learn the behavior of different kinds of wood, repeat the last exercise with a piece of walnut or cherry.

To turn a handle for a file or chisel, use the piece already used for Exercise 8 (a taper plug).

Exercise 10. Work from a model, and copy by eye, using no measurements.

A chisel-handle.

After your last exercise you will have little difficulty in finishing this all with the chisel. First mark off the length of the ferrule *a*, the position of the curve *bc* and the length *d*, as in the figure.

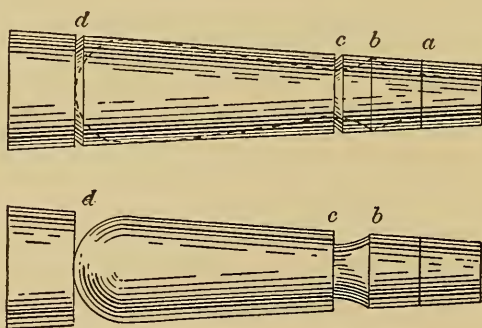


FIG. 18.

With the acute angle of the large chisel cut well down into the work at *c* and *d*, slightly at *a*, and make only a light mark at *b*. Place the point

of the heel or obtuse angle of the chisel against the work at *b*, a little to the left of the mark, and cut out part of the fillet *bc* down to the notch *c*. Next round off the end, cutting down to the notch *d*, a task very much the same as that of turning the bead. When cutting from left to right do not change hands, but, as before, hold the handle in your right hand and the blade of the tool in your left, as when cutting from right to left. The reasons for this have been given before. Now with the heel placed to the left of *c* cut from left to right, shaping and connecting the two surfaces at *c*.

It is possible to turn out a perfect form at once without these auxiliary cuts; but it is better, at least at first, to divide the operations thus into parts. Make several of these cuts if necessary, and repeat the operation until the convex and concave surfaces are gradually brought down to the desired shape and proper dimensions. This will give more practice for the chisel and eye, which at this stage is very important.

The small end is not to be finished, but left somewhat larger than is necessary, to be finished and fitted with a ferrule as a future exercise.

LESSON V.

CHUCK - WORK.

It is required to turn a ring with an external diameter of 3'' and a circular cross-section of $\frac{1}{2}$ '' diameter

Exercise 11.
A ring.

Glue together two pieces of pine each $\frac{3}{4}$ '' thick and $3\frac{1}{4}$ '' square. Remove the live-centre and put a small piece of waste in the hole of the spindle to keep out the dust. Screw on the face-plate, first cleaning thoroughly the threads of the spindle and the plate. The plate should run on with perfect ease, and it will do so if the threads are clean. As the face-plate approaches the shoulder of the spindle, bring it up into contact carefully and without using undue force. If it is jammed too tight it will be difficult to remove it without injuring the lathe, and besides the thread of the plate may ride up on that of the spindle and one or both be damaged.

Measure the diameter of the base of the taper screw of the face-plate at the bottom of the thread. Bore a hole of this size in the middle of the piece of wood and screw it fast to the face-plate, bringing it up into close contact.

Set the hand-rest perpendicular to the lathe bed or parallel to the face of the work, about $\frac{1}{4}$ " distant from it, and at a distance below the centre about equal to the thickness of the chisel, so that when the chisel or parting-tool lies flat on the rest the cutting edge shall be a very little below the centre. Holding the chisel flat on the rest, perpendicular to the face of the work and with the long edge

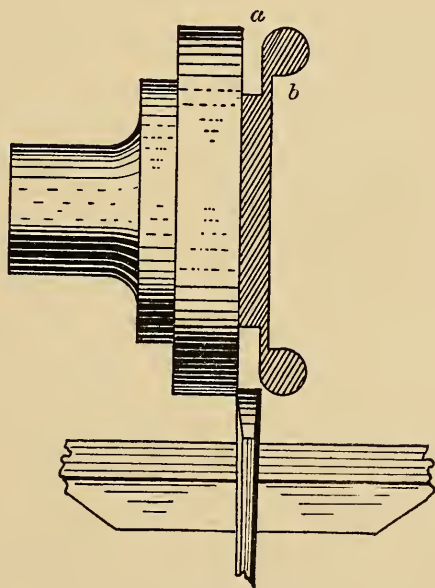


FIG. 19.

toward the right, turn down the piece to within $\frac{1}{16}$ " of its true size—that is, to a diameter of $3\frac{1}{16}$ ". Then, reversing the chisel, so that the long edge shall be towards the left, trim out the inside of the ring also to within $\frac{1}{16}$ " of its true size—that is, to a diameter $1\frac{5}{16}$ ", but only $\frac{3}{8}$ " in depth. Now

shift the hand-rest to its first position or parallel to the axis of the lathe and at the same height as before, and with the parting-tool placed $\frac{9}{16}$ " to the left of the face of the piece and perpendicular to the length of the lathe cut in about $\frac{5}{8}$ " deep.

You will observe that the parting tool is much thicker in the middle, having a diamond-shaped cross-section. This gives more clearance to the tool when it is used as a boring-tool or to cut a circle or to make a cut the exact size of the width of the tool. In the present case, however, there is plenty of room to spare, and you may make a cut a little wider than the tool, which will lessen the heating. You should cut lightly and run at a moderate speed, so as to avoid drawing the temper of the tool, which you may easily do if you force it too much. If this does happen it will be necessary to re temper the tool.

You have now turned the outside and inside diameters and the thickness of the ring to within $\frac{1}{16}$ " of its true size. Shape and finish it with the chisel and sand-paper. In doing this it is obvious that you cannot *cut* with the chisel, as you did in forming the file-handle, for instance. In that case the grain of the wood ran parallel to the axis of the lathe: in this it is everywhere perpendicular to the axis, and if you use your chisel as before it will dig in and mar the work. It is to be used now as a scraper, being held, not with its edge on

the rest, but with its flat face, and with its length perpendicular to the surface which is being cut; the direction of the motion of the revolving wood is then perpendicular to the cutting face of the tool, instead of being nearly parallel to it, as in Exercise 10.

After turning as much and as near to the required size as possible on the face-plate, cut the piece off by running the parting-tool or small chisel through at *b* in the figure, meeting the channel *a*, and the ring will then drop off on to the tool and will have a nearly circular cross-section.

To finish it you must use a "chuck" made from a piece of 1" pine about 5" square. Before doing this face off the remaining piece on the face-plate before taking it off, and glue to it a piece of cherry, maple, or other hard wood, $3\frac{1}{4}$ " square and about $\frac{5}{8}$ " thick, from which to turn another ring. While this is drying make the chuck and finish the ring.

Fasten the piece for the chuck to the face-plate as you did the piece just used and turn it to a circular form, leaving it as large as it will hold. Cut out the centre to a depth just half the thickness of the ring—that is,— $\frac{1}{4}$ " and of a diameter just large enough to hold the ring firmly, but not so tight that you will run the risk of breaking the ring in forcing it in. The bottom of the chuck and the cylindrical surface must be turned perfectly true.

In chucking work, and also in reversing it in the chuck, make sure that it is pushed in till it bears firmly all round against the bottom of the

recess. Then, using the chisel as a scraper and cutting very lightly, finish the ring, and smooth it with fine sandpaper. It can be removed and reversed any number of times without impairing the accuracy of the work provided the chuck is perfectly true.

To familiarize yourself with the behavior of different woods under the chisel, turn, from the piece of maple already prepared, a duplicate of the last exercise by eye.

Cut off a piece of black walnut about 8" long and $2\frac{1}{2}$ " square. Mount it and turn it to the largest possible diameter. Face off

Exercise 13. one end either plane or very slightly
Hollow work. concave, but certainly not convex.
A vase or wineglass.

Bore this end and fit it to the face-plate. The end being square, the piece should run true without the support of the centre; nevertheless, for greater safety, rough out and do all you can in such cases between face-plate and centre. The work is now balanced. Remove the tail-stock and bore the cylindrical cavity as in the last exercise, roughing it out with the small chisel. Before doing this make a mark upon the chisel at a distance from the point equal to the depth of the

required hollow. Continue the boring with the chisel until the mark on it coincides with the face of the work.

This hole, as will appear later, can be bored very well with the gouge, but not without danger unless the workman is very skilful, as the tool is apt to dig in and be jerked from the hand. Make a number of cuts, Fig. 20, each cut being suc-

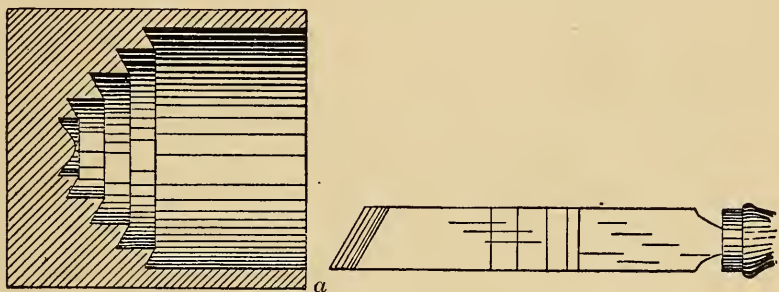


FIG. 20.

cessively about $\frac{1}{4}$ " larger in diameter and $\frac{1}{8}$ " less in depth than the preceding one, thus forming a series of steps on the inside, measurement being taken with a gauge, or by marking the chisel as before. The steps are now removed and the cavity roughed out with the same chisel, held with the acute angle reversed or turned toward the centre of the work, as in Fig. 21. Every tool that has a broad surface, when used as a scraper tends to make the work untrue or, in turning, eccentric: hence the objection to cutting too much with it at the thin portion *a* in the figure. As the gouge is

not a safe tool in the hands of a beginner for finishing the curved bottom, this may be done with

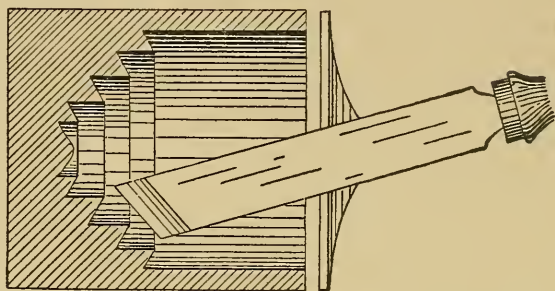


FIG. 21.

a "round-nosed" or "face" tool, Fig. 22, made for the purpose from a flat bar of steel or an old file ground down thin at the cutting edge.

As this is your first attempt at hollow or inside cutting, it is well to finish all hollowing out be-

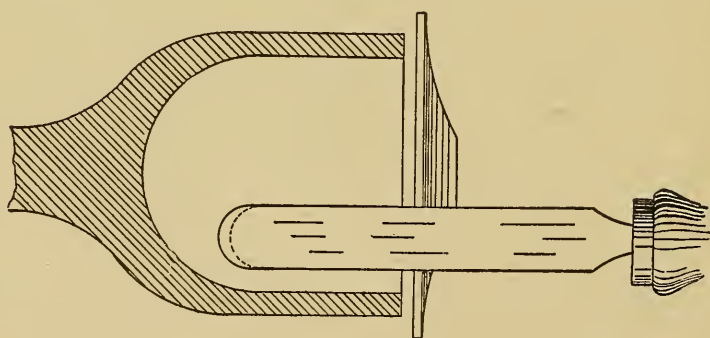


FIG. 22.

fore commencing work on the outer portion, as the work is more firm and is not so apt to chatter and snap off as it would be after having been partly

turned on the outside. In rounding off the outside of the cup the chisel should be used as a scraping-tool after the hollow has been roughed out with the chisel and gouge. If used as a cutting-tool it is likely to dig in, on account of the springy nature of the hollow.

Now bring up the tail-centre very gently, allowing it to make its own centre gradually while the piece is revolving. Clamp it fast, and with the

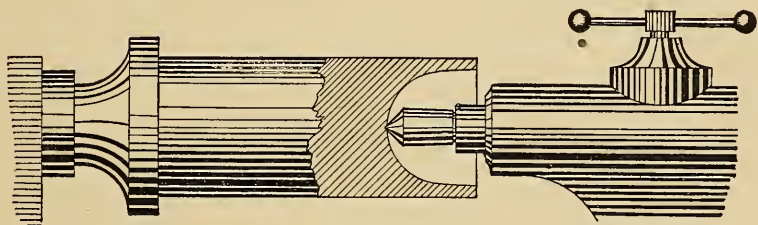


FIG. 23.

work between face-plate and centre turn and finish the outside as you did the file-handle. First mark out the depth of the hollow *a*, Fig. 24, the length of the bowl *b*, and the base *c* and *c*, as in the file-handle exercise. Using the acute edge of the large chisel, insert the point well down into the work at *b*, making a notch as shown in the figure, and pare or cut down and partly round it off as in the last exercise. With the acute angle make another cut and pare down to it. Repeat the operation until the bowl is nearly completed, turn to the true dimensions, and make the thin portion of the inside

of the bowl at *d* concentric, or perfectly true, with a small, round-nose tool, and finish with the large chisel held as a scraping-tool.

Rough out the middle portion or stem first with the small gouge and chisel, finishing the fillets and beads with the special tools. Finish the stem and all the curved parts nearest the bowl first and

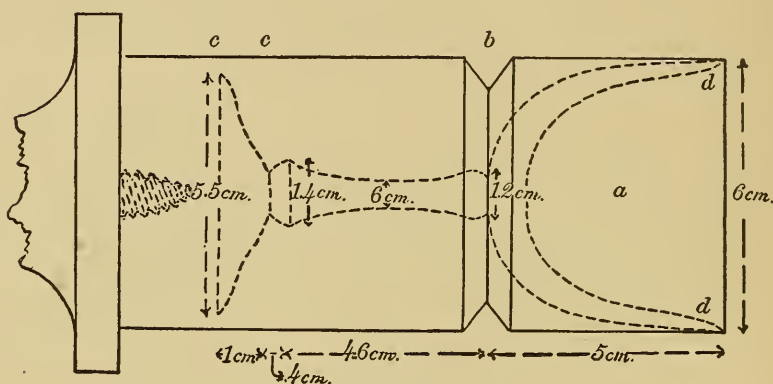


FIG. 24.

gradually work toward the base of the cup in order to prevent twisting and breaking the stem.

Great care must be taken not to let the chisel or gouge slip and dig in, especially in working near the bowl at *b*. A dull tool is ever ready to do this and should not be used.

In an exercise of this kind when the design is more complicated, with many curves of different radii, several special tools are necessary, called pattern-maker's tools. They are all made in the

same way as the one just used and can be easily altered and adapted to any kind of work. For light fancy turning such tools exclusively are used, at least after the first roughing out.

For further practice in such work as the last, if there is abundance of time, the following variations may be made: Pieces of maple, cherry, and other woods being glued together, the grain running parallel to the axis of the proposed object, and one of the pieces being exactly central, so that the colors shall be symmetrically arranged, a pleasing variety of effect will be obtained. In this way a duplicate of the last exercise may be made by eye, or the card-receiver, a vase with broad and shallow bowl, may be turned.

Exercise 14.
A broad vase
or card-re-
ceiver.

Centre the piece exactly at the middle of one of the colored pieces and, between centres, turn to the largest possible cylinder. If the piece has been correctly centred, and the several thicknesses were properly prepared, the stripes of color will be symmetrical. Face off the end, bore it and fit it to the face-plate, and then at a low speed and with a light cut turn the outside true. When it is quite true and perfectly balanced, run at a higher speed and turn the cavity for the base, which should be slightly concave, and bore and fit this end to the face-plate. Now cut out the top and finish it to the shape and size given in

the drawing or model, and then, as in Exercise 13, bring the tail-centre up. Rough out and nearly finish the work between centre and face-plate, relaxing the pressure of the centre as the stem gets near the true size, so as to lessen the risk of breaking, but without removing the centre altogether. For the same reason great care must be taken to use sharp tools and light cuts, and to make special tools for particular parts.

For repetition of the operations of Exercises

Exercise 15. 9, 10, etc., in various woods, an egg-shaped solid, an Indian club, and other such objects may, if time allows, be made from plain hard wood or from colored woods glued together. The work should always be done from drawings, and should be exact to measurement. These exercises involve no new principles and are not necessary, except for the purpose of acquiring quickness and precision.

LESSON VI.

PATTERN-MAKING.

THE preparation of a suitable pattern for a casting requires a knowledge of the properties of the wood from which the pattern is to be made, the process of working it in the lathe or at the bench to any desired form, the process of making a casting from it, and the process of finishing the casting to its proper form and dimensions. This knowledge your previous exercises have already furnished, and you have now to apply it.

You remember that wood shrinks and warps, and you will endeavor to prevent this, or to counteract its effect by making allowance for the shrinking and by building up the pattern of pieces with their grain in different directions to prevent the warping. You will have to study with care the drawings of a given pattern, and so design it as to give it the greatest possible strength. As the sand is to be packed closely round it, you will have to consider the "draught" or inclination of its sides to allow it to be easily

removed from the mould. As the metal will shrink in cooling, you must make the proper allowance for this in designing the pattern. Finally, as the casting will have to be finished up, allowance must be made also for the loss of size in the process of finishing.

The amount of "draught" needed for a small pattern is much less than that given to a large one. A very thin pattern can be made with its sides almost parallel, while for a pattern, or any part of one, which enters deeply into the mould or flask a draught of $\frac{1}{8}$ " or $\frac{1}{4}$ " to the foot is given.

The allowance for shrinkage of the metal depends very much upon the shape and the size of the pattern. The shrinkage is the greatest where there is the greatest amount of metal.

It is found in practice that in all patterns about 4" or less in any direction no allowance need be made for shrinkage, as the jarring necessary to loosen the pattern from the sand enlarges the mould enough to make up for the shrinkage, so that a casting of this size will be of the exact size of the pattern. Above this size, however, the casting will be smaller than the pattern.

The usual allowance made for the contraction of the casting in cast iron is a little less than $\frac{1}{10}$ " per foot, and for brass $\frac{1}{8}$ " per foot and over, as you have learned in your course in moulding.

First glue up and turn a simple cylinder pat-

tern for a casting which is to be turned and finished to a diameter of $3\frac{3}{4}$ " and a length of 8". Make the proper allowance for shrinkage, and for turning in the metal lathe. The size then for the pattern will be : diameter, $3\frac{3}{4}$ ", plus $\frac{1}{8}$ " per foot for shrinkage, plus $\frac{1}{8}$ " for the surface, or $3\frac{7}{8}$ "; length, 8", plus $\frac{1}{8}$ " per foot, plus $\frac{1}{4}$ ", or $8\frac{3}{8}$ ".

Cut off four pieces of pine $1" \times 4" \times 10"$. Test the pieces to see if they are winding, and if you find them straight glue them together in twos, making two pieces $2" \times 4" \times 10"$.

To do this, first see if the glue is of the proper consistency ; it is a waste of time to use the glue before it is in proper condition. This is a very important point in pattern-making. The room should be warm, the glue hot and not too thin or thick, and the pieces should be heated.

You have learned from your soldering and welding exercises that the closer metal and metal are brought together the stronger will be the joint, and the same is true in glueing—the closer the pieces are brought together by rubbing and pressing out all excess of glue (if it is in proper condition) the stronger will the joint be. Glue and fasten the pieces together with the screw-clamps.

This pattern is composed of two halves, and is to be moulded in a two-part flask (such as you have used in moulding.)

Exercise 16.
A pattern for a cylinder.

The line *aa* shows the division of the pattern. Glue the pieces together, but at the end only, for about $\frac{1}{2}$ " of their length, and you will then have a piece 4" square and 10" long. The parting-line being at *aa*, care must be taken to centre the piece exactly on this line, so that when the pattern is turned and the joint broken or separated the pieces

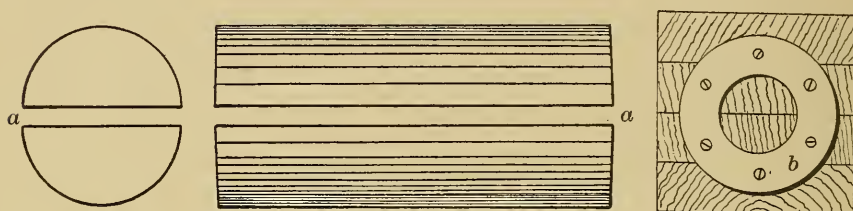


FIG. 25.

shall be exact semi-cylinders. In large work (and it will be safer in this case) clamps are fastened to the ends of the pieces to hold them together. Fasten to the ends the washers, *b, b*, provided for the purpose, with the hole enlarged to admit the centres. Without these washers the work is apt, from a jar or shock, to break apart. It is not necessary, however, to use them in very small work.

After turning the piece to the proper diameter ($3\frac{3}{4}" + \frac{1}{8}" \text{ per foot} + \frac{1}{8}" = 3\frac{7}{8}"$), before separating the pieces, bore and fit two dowel-pins, one at each end. The length of the piece is now 2" too great. Bore the holes for the dowels, one hole 2" and the other $2\frac{1}{4}"$ from the ends, perpendicular

to the plane surface, and 3" deep, piercing but not boring through the bottom half *b*. The object in fitting one dowel-pin nearer the end than the other is to insure the putting of the parts of the pattern together in the position in which they were turned. If put together in the reverse position in the mould they might not form a perfect cylinder. Mark and cut off the pins, which should fit snugly, but not too tight, in the upper half of the pattern, put a little glue on the pins near the top, and drive them into place.

With the parting-tool cut off 1", or the amount necessary, from each end to make the pattern of the exact length, $8'' + \frac{1}{8}''$ per foot $+ \frac{1}{4}'' = 8\frac{3}{8}''$,

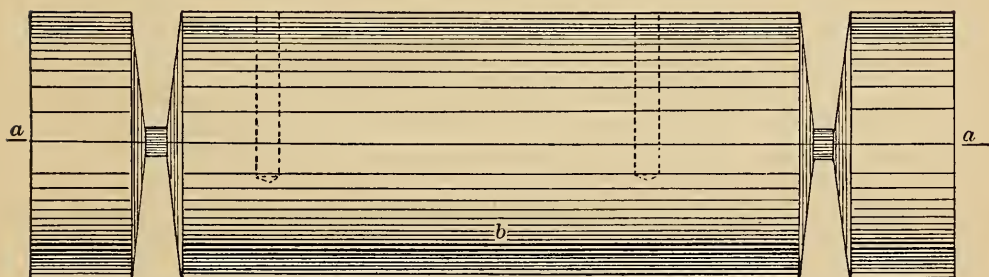


FIG. 26.

giving it also the proper draught. This waste at each end will remove the holes made by the screws to fasten on the washers, and also the part in the line *aa* of division which has been glued. When these ends are cut off with the back-saw the parts of the pattern will easily separate. If

you find, however, the pins fit too tight, rub them a little with sandpaper. They should fit easy, but without shake. Shellac the pattern, giving the ends two coats, and when it is dry it will be ready for use.

Next turn a pattern for a simple hollow cylinder 4" long and 4" in diameter. The casting from **Exercise 17.** this pattern is to be used as an exercise on the metal lathe, and to be finished all over, faced, turned, and bored. Allowance must be made for shrinkage as in the last exercise, and also for the turning and finishing up of the casting to the given dimensions.

As the cylinder is to be cast hollow, or with a hole clear through it, provision must be made for coring. To do this, add to the length of the cylinder about 4" for the core-prints.

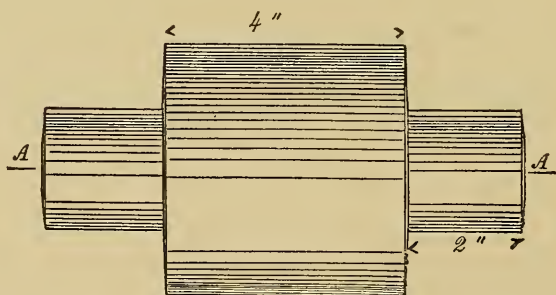


FIG. 27.

While the core-prints *A, A* form a part of the pattern, they will not be a part of the casting, and they are generally distinguished from the pattern

by being painted black. They are added to the pattern to form an impression in the sand into which the core (the exact size of the print) can be laid and supported in the mould.

A is the core and *BB* the space round the core into which the metal flows and thus forms the cast-

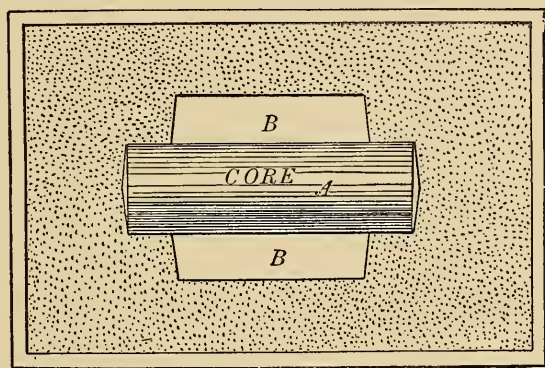


FIG. 28.

ing without displacing the core, as it is held firmly between the upper and lower moulds, or “nowel and cope,” as they are called. The diameter of the prints should be $\frac{1}{4}$ ” less than the bore of the cylinder.

Glue up the pieces, turn, bore, fit, and cut them off, all as in the last exercise.

The pattern-maker understands that, while he is to make the whole pattern larger to allow for shrinkage, allowance for the metal machine tool is made only where a crow-foot X, or the words “finished size” appear on the drawing. Then the length of this pattern when finished will be the

Exercise 18.

A built-up pattern for a cylinder and steam-chest.

length given in the drawing, Fig. 29 (which shows the finished casting), plus the shrinkage, plus allowance for the metal-tool, plus the length necessary for the core-prints; and the diameter will be the diameter of the flanges, plus the shrink-

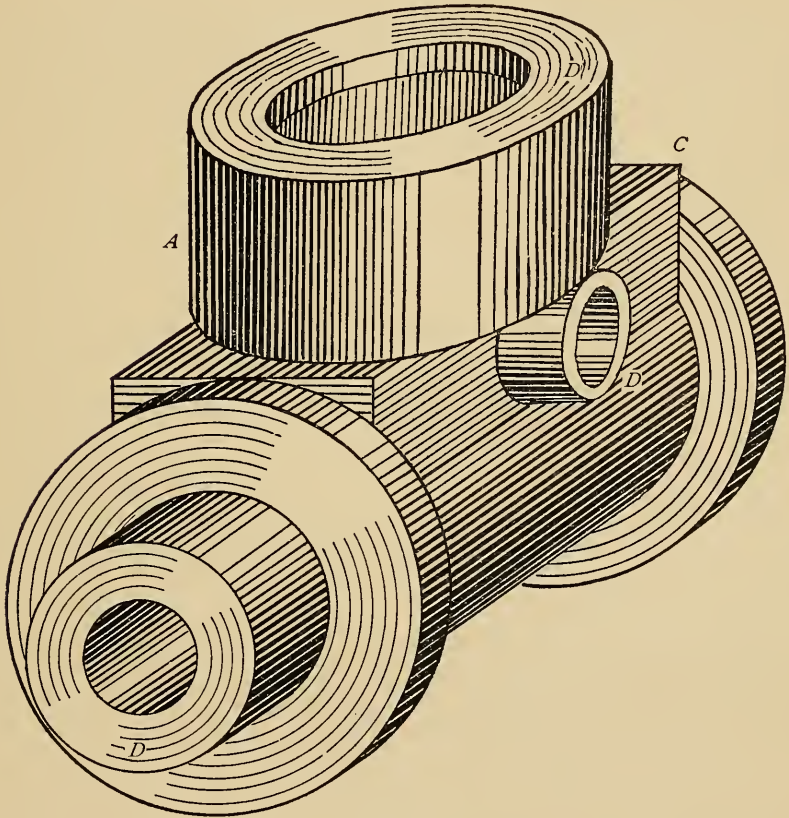


FIG. 30.

age, plus the allowance for the tool. Allowance for shrinkage and the tool is made in the same way for the steam-chest *A*. As there is to be no turning of the metal between the flanges, no allowance

need be made in the diameter of the cylinder except for shrinkage. The pattern for this casting is shown in Fig. 30, omitting the core-prints at *D*. The dimensions must be found, from those given in Fig. 29, by adding the proper allowances.

First, glue up and turn, as in the last exercise, the simple cylinder as shown in the detail drawing, Fig. 31, turning the grooves *a, a* for the flanges.

Second, turn and fit the flanges or rings.

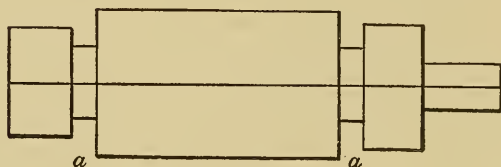


FIG. 31.

Third, make and glue on the flat seat *C* for the steam-chest.

To make and fit the rings, fasten to the face-plate a piece of pine, large enough for a face-plate, and screw it fast, as you did the piece for a chuck in the ring exercise. Face it off true and find the centre by holding up to the revolving piece your lead pencil, supported upon the T of the hand-rest, making a little dot by touching it gently. Draw a line through this point across the grain of the wood and fasten one of the pieces for the flanges (which are to be in two halves) to this

face-plate with screws, taking care to have the edge *aa* coincide with the line drawn through the point on the face-plate.

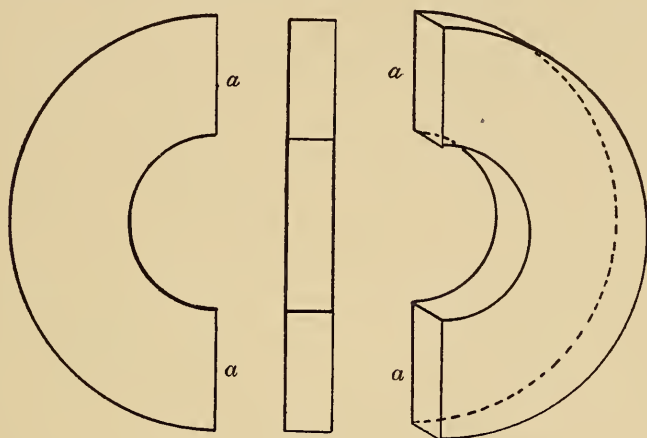


FIG. 32.

Fasten in the same manner the second half, sliding it up to the edge of the first piece. It will then be ready for turning. Turn the outside diameter $\frac{1}{4}$ " larger and the inside diameter $\frac{1}{8}$ " smaller than the pattern, and make the thickness $\frac{1}{8}$ "

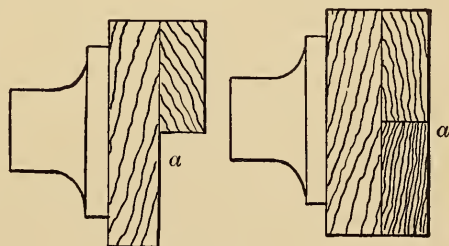


FIG. 33.

larger than the width of the grooves *aa* in the cylinder. Be sure the face is square with the inside diameter before removing the pieces from the face-plate. The halves should be exactly alike when compared.

If the pieces are square and true, remove them

from the face-plate, remount the cylinder, and finish the grooves to fit the flanges accurately. Use the flanges as you would the calipers, trying them frequently in the grooves. When they are fitted, glue the pieces to the cylinder, being very careful to have the ends *a, a*, Fig. 32, agree with the line of division on the cylinder. If the grooves are well smeared with glue it will not be necessary to put any glue on the flange-pieces, but only to rub them down well in place, pressing out all excess of glue. After scraping off all the glue, if there is any, between the ends *a, a*, clamp them to the cylinder with the clamp-screws.

When this is dry, remove the clamps and turn and finish the flange part of the pattern and the core-print, as shown in the sketch. As this is a difficult pattern to draw from the sand, give the proper draught, not only to the pattern proper, but to all the prints as well.

Turn and finish in the same manner the cylinder for the steam-chest and then glue it on to the steam-cylinder, as in the drawing, Fig. 30.

The hollow cylinder, Fig. 34, is to be cut into rings in a later exercise (Part II., Lesson 13, Piston-rings). You have already learned (Ex. 17) how to make a pattern with core-prints for such a cylinder; the same object may now be made from the pattern shown, without a core.

Exercise 19.
A pattern for
a hollow
cylinder
without
prints.

As this pattern will be fragile, it is to be built up of several layers or rings, as shown in the elevation *A*, each ring consisting, as shown in the

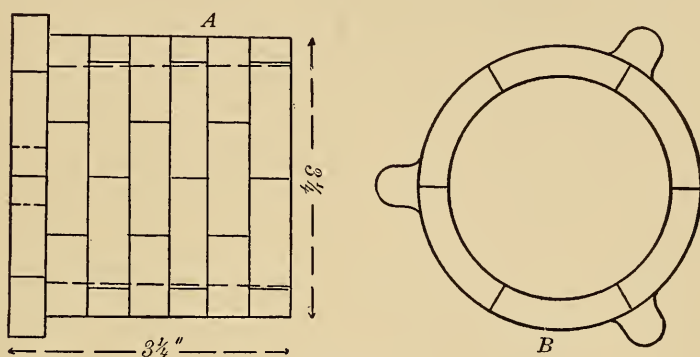


FIG. 34.

plan *B*, of several segments, all of which have the grain of the wood running lengthwise.

First make a template by dividing off the ring between two properly drawn circles into 6 equal

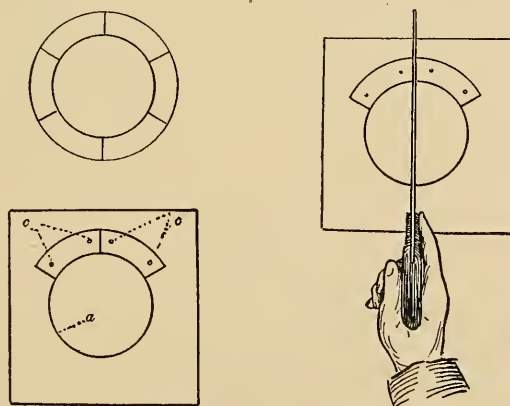


FIG. 35.

parts, Fig. 35. Using one of these segments as a template, mark out parallel with the grain of the

wood a sufficient number of pieces to build up the pattern, and saw them out.

Build the first course upon a piece of wood, say cherry or maple, 6" square. First with the compasses describe a circle $\frac{1}{4}$ " smaller than the inside diameter of the pattern. Place two of the segments upon the block with their ends touching and their inside edges coinciding with the circle, Fig. 35. Fasten them to the block temporarily with four small brads, and saw through the joint carefully with the back-saw, Fig. 35. If, after removing the brads and bringing the ends up together again they do not fit accurately run the saw through a second time. If the pieces are marked and sawn out carefully from the template, they ought to fit after running the saw through

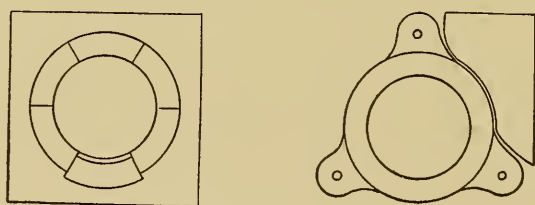


FIG. 36.

the joint the first time. Fit all the joints in the same manner. The last segment may be a little long, so that as it is brought up to the circle, Fig. 36, it will need sawing two or three times through the joint to make the edge and the circle agree. Upon the block as a foundation the seg-

ments of the first course are to be glued, each one being glued on its side face to the base-board and its end to its next segment.

The segments of the second course are glued to the first in the same manner, but breaking joints, that is, with the joints opposite the middles of the pieces of the first course, as in Fig. 34, so that alternate joints will lie in the same plane. Fit and glue up in this manner a sufficient number of courses to make the pattern of the proper length.

When the glue is thoroughly dry turn and finish the pattern, very much the same as you did the cup or card-receiver. Make allowance for shrinkage, etc., as in the preceding exercise in pattern-turning. After it has been turned and finished cut out the lugs, Fig. 36, with the back- and compass-saws to make the casting as light as possible. The lugs are used to bolt the casting to the face-plate of the engine-lathe, in a later exercise.

LESSON VII.

BRASS-TURNING.

THE methods and processes in brass-turning are similar to those in wood-turning, but the tools used are held more firmly on the hand-rest, because brass is much harder than wood. The same speed may be used as in turning hard woods, and also some of the tools used, first softening them a little by lowering the temper to a straw color. The top-rake also, if there is any, must be ground off, because the advantage gained by the top-rake in assisting the tool to cut freely is more than counterbalanced by its tendency to dig into the work, spoiling it, and often breaking the point of the tool.

You have learned by experience that it is almost impossible to turn woodwork absolutely true with the chisel without having first used the gouge or a similar tool in roughing out and turning it true and nearly of the required dimensions. As the flatter-tool in blacksmithing, the smoothing-plane in carpentry, and the chisel in wood-turning

are used for finishing, and not for roughing out, so in metal-working, the broad finishing-tool should be preceded by a roughing-out tool. Such roughing-out tool is most commonly the graver.

This is made from a bar of square steel or an old square file, by grinding the end obliquely to

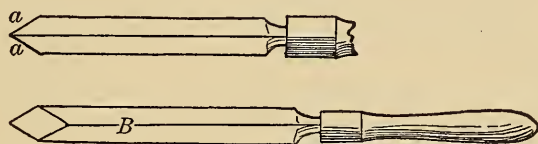


FIG. 37.

form the cutting edges *a, a*. *B* is the heel of the tool, used as pivot, and rests on the T as a fulcrum.

For parallel turning the straight flat-faced tool (Fig. 38) is the best. The lower surface, shown in elevation at *c*, is round, the upper, *b*, is flat, not



FIG. 38.

hollow as in the gouge for wood-turning. The cutting edge may be round-nosed or diamond-shaped. The method of holding and operating the tool is to grasp the handle in the right hand and place the tool on the top of the T, holding it down with the thumb of the left hand, with the fingers round the socket of the rest, as in Fig. 39.

way up to the shoulder, and with the graver face off the end square. The parting or square-nosed tool might be used here, but it is better to learn to face with the graver, thus avoiding loss of time in changing tools. Cut with the broad face of the tool, with one of the top faces resting upon the hand-rest, as in Fig. 40. Scrape off the burr made

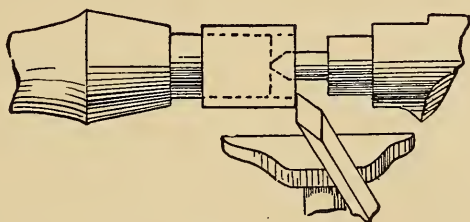


FIG. 40.

by the hand-tool, and if the end is true reverse the ferrule, drive it up to the shoulder, and face off the other end.

The tool can be used as a roughing-, a finishing-, and a facing-tool. To use it as a roughing-tool to turn and true up the ferrule, grip the handle in your right hand with the knuckles below, and with the left grasp the tool close to the hand-rest, holding the edge or heel *B* firmly to the face of the *T*, with the knuckles on top. The work can be turned very true and parallel if proper care be taken to make the point of the tool move in a line parallel to the axis of the lathe. This can be accomplished by means of two motions of rotation which are to be made together: First. If

the tool be turned around the heel *B*, which is resting in a horizontal position on the T rest, the point will be carried round the circumference of a small vertical circle, reaching its highest point

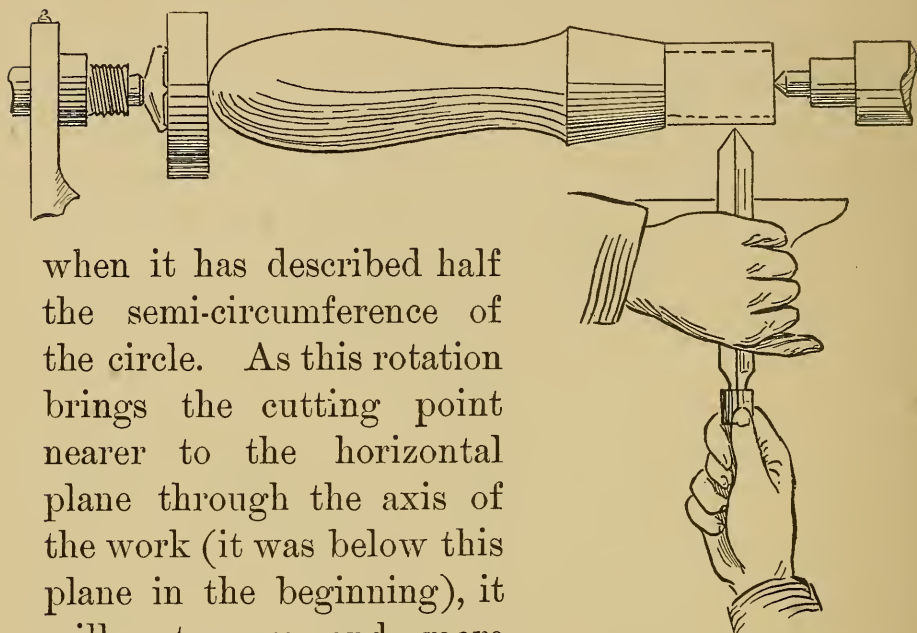


FIG. 41.

when it has described half the semi-circumference of the circle. As this rotation brings the cutting point nearer to the horizontal plane through the axis of the work (it was below this plane in the beginning), it will cut more and more deeply till it reaches its highest point, and then again less and less deeply. With this movement alone, therefore, it would be impossible to cut a cylindrical surface.

Second. If the tool be turned round a vertical axis at the point where the heel *B* touches the rest, the cutting point will describe a portion of the circumference of a horizontal circle, coming nearest to the axis of the work at the moment when the tool is perpendicular to the axis of the lathe. This

movement also, by itself, would cut a groove in the work, instead of turning it to a cylindrical surface.

Let these two movements be called the vertical and the horizontal movement respectively, and let each be divided into two halves. During the first half of the vertical movement the depth of the cut increases, and during the second it decreases. During the first part of the horizontal movement the depth of the cut increases (the hand being carried from right to left, and therefore the cutting point from left to right), and during the second it decreases. If, therefore, the second half of the horizontal movement be commenced simultaneously with the first half of the vertical movement, and this same horizontal movement be reversed during the second half of the vertical movement, it will be possible so to adjust the rates of the two as to cause the cutting point to move in a straight line and cut a cylindrical surface.

Practise the two movements separately, holding the cutting point at a short distance from the work, so as not to cut. Then, in the same way, practise them in combination. Lastly, apply the point to the work and, taking very light cuts at first, turn the surface truly cylindrical. As the ferrule is thin and might be cut through in practising, it will be best to turn, first, a solid cylinder.

From a piece of $\frac{1}{2}$ " round brass rod turn a

cylinder true and parallel. First screw on the chuck. Remember the precautions **Exercise 21.** to be taken in screwing on the face-plate, and use the same, and if possible greater care, with the chuck, particularly if the chuck is a loose rather than a close fit on the spindle and offers no resistance. There is even more risk in the case of the chuck than in that of the face-plate of bringing it up to the shoulder too quickly and jamming it, for the reason that it is heavier, and has, therefore, more momentum.

The chuck is a very delicate tool, easily injured and made useless for accurate work; hence very great pains should be taken to screw it on and off the spindle carefully. As the chuck approaches the shoulder of the spindle bring it up into contact gently, and without using undue force. If it is jammed too tight it will be difficult to remove it without injuring the lathe, and besides the thread of the chuck may ride up on that of the spindle and one or both be damaged.

A piece of round brass half an inch thick and 3" long is provided, from which to turn a cylinder $\frac{3}{8}$ " in diameter and $1\frac{1}{2}$ " long with the graver-tool.

Fasten the piece of brass in the chuck with the end projecting about 2" from the jaws of the chuck, and with the centring-tool centre the end.

The centring-tool is made by grinding the end of an old saw-file at an angle equal to the angle of the lathe-centre, as shown in figure 43. The edge *a*

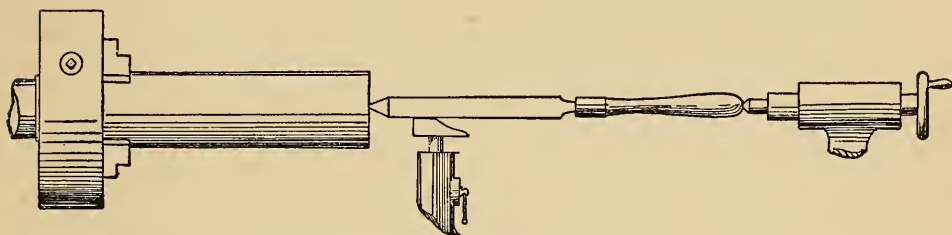


FIG. 42.

and not *b* and *c* being the cutting part, the edges *b* and *c* are purposely ground off a little so that

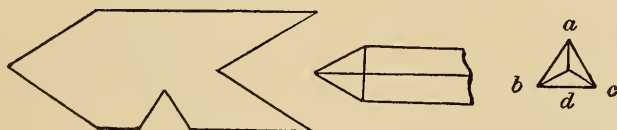


FIG. 43.

only one edge, *a*, shall cut. Bore a hole with an awl or make a mark with a centre-punch at the end of the handle and the tool will be ready for use.

Set the T rest about $\frac{1}{2}$ " from the end of the work and at right angles to the axis of the work. The end of the work must be faced quite true, if not so already. Place the point of the tool at the end and as near the centre of the work as you are able to judge, and slide the tail-stock down to it till the tail-centre enters the centre in the handle of the tool and the tool is suspended between the brass

Exercise 22.
Centring
with the cen-
tring-tool.

and the centre. Adjust the height of the T rest so that when the flat face d is rested upon it with the edge and corner a up, the point shall be about $\frac{1}{32}$ " below the centre.

Grasp the handle in your left hand, start the lathe in motion, and you will feel the tool wobble or rotate a little if the point is not exactly at the centre of the work. To stop this eccentric motion and to centre the work perfectly true requires some skill in handling the tool. The tail-centre being placed in the hole in the end of the wooden handle, hold the tool with the flat face down and parallel to the top of the T rest, but not touching it. When the point has entered the metal about $\frac{1}{16}$ " steady the tool upon the rest by allowing the tool to turn till one of its edges touches the T. The corner being supported upon the T rest as a fulcrum and the edges at b and c being rounded off, leaving but one edge a to cut, the tool has a tendency to feed itself in towards the centre. It is necessary, therefore, to do this very carefully and retain complete control over the tool to prevent its chattering or springing into the work.

Hold the corner of the tool as just described firmly on the rest, and feed the tool in slowly till a true centre is obtained, which will be the case when this rotary movement of the tool ceases. Now remove the centring-tool and support the

piece between the chuck and the dead-centre. Set the rest at a convenient distance (about $\frac{3}{8}$ ") from the work.

Adjust the height of the rest so that when the graver is resting upon it and held in the proper position the point shall be on a level with the point of the dead-centre.

Run at a moderate speed, with the belt on the middle step of the cone. As in wood-turning, so in brass-work, all play which may have resulted from the wearing away of the metal at the centre should be taken up. There is danger if you

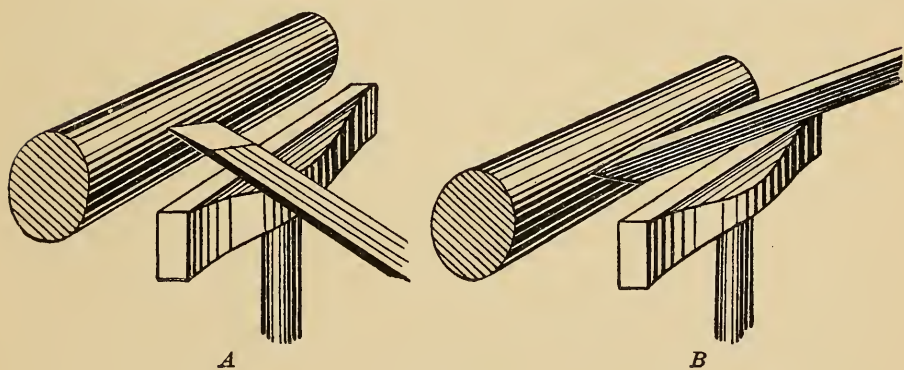


FIG. 44.

cut too deep, or if the work is loose in the centre, of having the tool jerked out of your hand, or forcing the work out of the centre, spoiling the centre, and sometimes breaking off the point of the centre.

When you have turned your work true and parallel with the point of the graver finish it smooth

with the same tool, cutting and scraping with the broad face of the tool.

In using the graver thus as a finishing-tool, to cut smoothly place the heel of the tool upon the T and slide the tool along. The edges *a, a*, Fig. 43, will do the cutting. The same tool may be used as a scraper or as a cutting-tool, according to the manner in which it is held upon the rest and applied to the work.

Fig. 44 shows at *A* and *B* the two positions of the tool, as cutter and as scraper respectively.

For further practice with the graver, reverse the piece in the chuck and turn the end to a conical form, as nearly to the angle of the lathe-centre as you can judge by the eye, and then remove the centre and turn to a fine point to fit the centre-gauge.

Remove the chuck, mount the file-handle between centres, and finish the ferrule with the graver, file, and emery-paper.

Cut off a piece of $\frac{1}{2}$ " round brass $2\frac{1}{2}$ " long.

Exercise 24. Screw on the chuck carefully. Grip the piece of brass in the chuck, with the end projecting out far enough to allow the work to be turned and finished.

For all light turning, if the work does not project too far from the face of the chuck, the centre may be dispensed with, which will give more room. Work as close to the chuck as possible,

and with the graver-tool turn and fit the plug to the hole in the cap of the brass bearing of the lathe-spindle. Rough out as in the last exercise with the point of the tool and face down the shoulder *a* as in the ferrule exercise. As in the

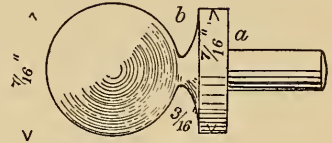


FIG. 45.

ring exercise in wood turning, so in this case finish all you can of the knob or ball before cutting it off. With the round-nose tool turn out the fillet *b* to the proper depth.

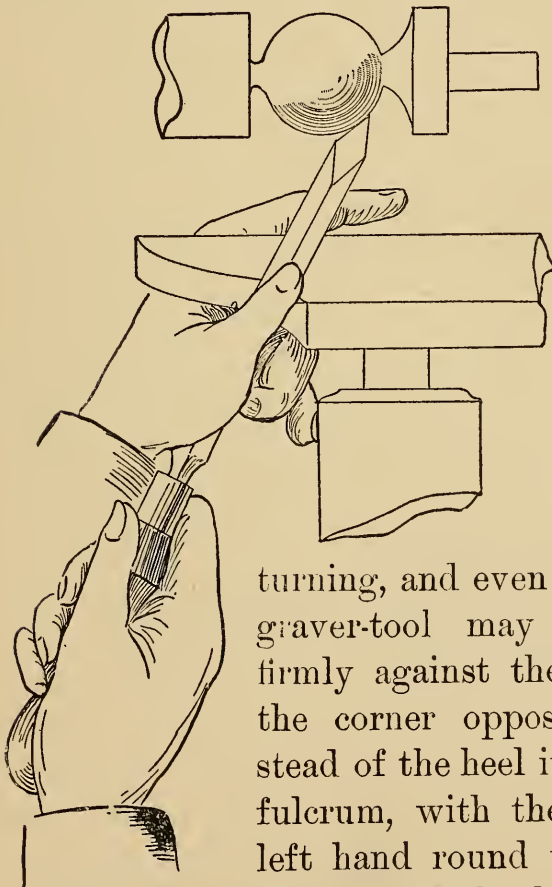


FIG. 46.

For very delicate light turning, and even in this case, the graver-tool may be used, held firmly against the hand-rest, with the corner opposite the heel instead of the heel itself serving as a fulcrum, with the fingers of the left hand round the T, or better, the stem of the hand-rest, and the thumb pressed down on top of the tool to steady

and guide it. The tool held in this position serves as a cutting-tool, and if not gripped firmly is more likely to dig into the work than when applied in the reverse position and used as a scraper. With the tool in the position shown, finish and cut off the plug. Grip the small end in the chuck and finish the ball.

From the piece of brass left in the last exercise turn the binding-post and screw, Fig. 47, to dimensions.

Exercise 25. Turn and finish up with the graver and round-nose tool, as in the last exercise, and with the knurling-tool mill the ends. This tool is a little roller or knurl, revolving on a hardened-steel pin between the jaws of the holder. On this roller teeth are cut similar to the teeth of a file. With each holder several knurls are furnished, differing in form and cut or pitch, and from these one can be

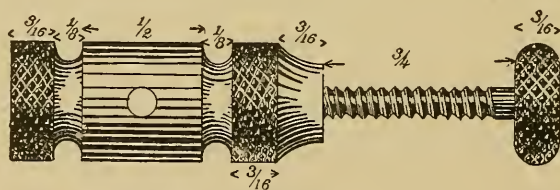


FIG. 47.

selected best adapted to the work. In this particular case the plain disk may be used.

Hold the tool firmly supported on the hand-rest. Adjust the rest for height and distance from the

work so that when the tool is resting upon it and held in a horizontal position the centre of the knurl shall be below the centre of the work, cutting under rather than above the work. Examine the tool before using it. The cutter should revolve freely and not bind when applied to the work, and it must be oiled frequently. Start the lathe in motion and apply the tool, pressing the tool upward as a lever rather than directly thrusting it against the work. This pressure against the soft brass will reproduce the teeth cut on the knurl.

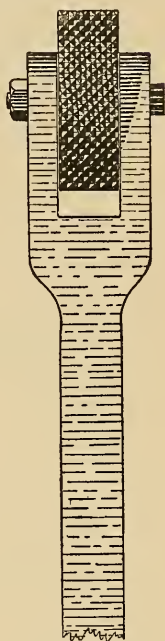


FIG. 48.

Centre with the hand centring-tool, and drill a hole 1" deep in the end of the piece with a drill whose diameter is equal to that of the bottom of the thread on the tap to be used. The hole is then called a tapping-hole and the drill a tapping drill. Fasten this drill in the drill-chuck provided for the purpose. This chuck is self-centring. It is attached to a mandrel which fits the hole in the spindle, and in the end of the mandrel is a centre. There is inside of the chuck a revolving disk with a coil or thread cut upon its inside surface and a corresponding thread on the surface of the jaws. To open or close the jaws it is only necessary to turn this disk

Exercise 26.
Centring and drilling.

by means of a steel pin inserted in a hole provided for this purpose. The point of the drill being placed in the centre made in the metal by the centring-tool, and the tail-centre being inserted in

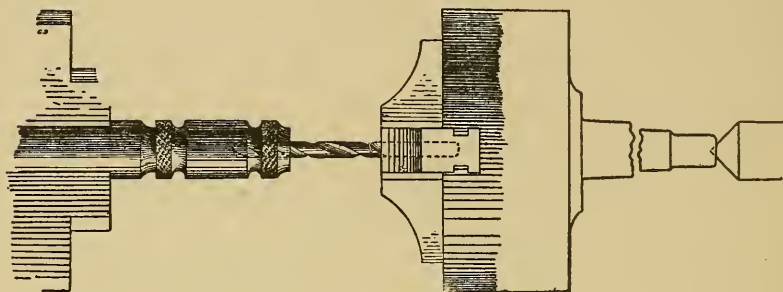


FIG. 49.

the end of the mandrel, the drill is then pressed forward with the dead-centre by the right hand, while the chuck is gripped with the left to prevent it and the drill from turning.

You have learned from your experience in drilling with the common flat drill, the most simple in form, the necessity of entering the metal very carefully at first, till a depth sufficient to drill a cavity the full diameter of the drill has been cut. After this has been done the tool is not so apt to run or spring away from its cut, as it is supported all round by the metal. If the drill has entered this depth without springing away from its centre, and is true, it may be fed in to the proper depth, 1".

This drill is called a twist-drill from the fact of

its having two helices cut from end to end. It is very nearly round and cylindrical, being only very slightly tapering from the cutting end to the shank, and the diameter is ground away at *a*, a short distance from behind the cutting edge to give clearance. The advantages of this drill are



FIG. 50.

that it always runs true, and if it breaks requires no forging or tempering. It offers very little resistance in cutting, but time must be given for the drill to cut and for the dirt or shavings to escape, otherwise it will heat and lose its temper and possibly break.

The tap is a very delicate tool, while the drill is considered one of the strongest. Taps are used to cut the threads of nuts. They are of two kinds, machine and hand-taps. The advantage the machine-tap has over the hand-tap is that all the cutting can be done with one tap, without the necessity of backing or unscrewing it to free the cuttings, thus saving much time. In order to accomplish this the machine-tap is made much longer. The threaded end is turned with a long taper (Fig. 51). The end at *a* is turned a little smaller than the core or bottom of the thread

at *b*, and the end *c* is squared to receive a socket or wrench. Between *b* and *c* is the shank, which is also turned down to the diameter of the bottom of the thread and left long to receive the nuts. This long taper allows the tap to cut free and easily. If this tap is screwed through the hole in the nut or piece of work a full thread will be cut and the work passed along to the shank, which is made long for the purpose. When a sufficient



FIG. 51.

amount of work has been tapped to fill the shank the machine is stopped, the work removed, and the shank again filled if necessary.

When the hole to be tapped has a bottom (as in this exercise or as in the case of the holes in the head- and the tail-stocks which receive the cap-screws to hold down the brass bearings) and the tap cannot be screwed through, hand-taps must be used.

Hand-taps for general use (above $\frac{1}{8}$ " in diameter) are made in sets, three taps generally forming a set, and called the taper, plug, and bottoming taps. The first tap (Fig. 52, *A*) is made tapering almost from end to end, the end, as in the machine-tap, being of the same size as the hole to

be tapped or the bottom of the thread. The second or plug tap, which follows the taper tap, is also turned tapering, but only for a short distance—a distance about equal to the diameter of the hole to be tapped or in some cases about the diameter of the tap. The third or bottoming tap (Fig. 52, *B*) is left cylindrical the whole length of the threaded part.

To form the cutting edges or teeth the tap is

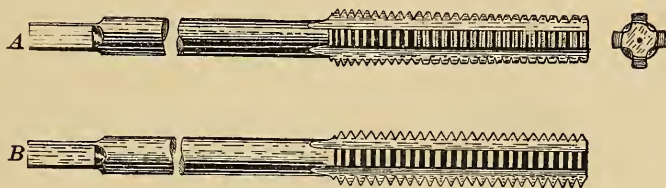


FIG. 52.

made with four (in some cases only three) grooves cut the whole length of the threaded end. The cutters or teeth, like the cutters of the twist-drill, are backed off a little with a file, or in the machine, to give clearance and reduce the friction.

As the tap must retain its size and shape without being easily dulled by use, it is hardened to a very high temper. All taps are made to standard sizes and of uniform pitch, so that the bolts and nuts are interchangeable. The pitch is the distance between two threads measured parallel to the axis of the tap.

The section of the thread for all small taps and those for general use is V-shaped, while for large taps it is square.

The friction, the depth of thread and the rake given to the teeth (which is the amount of inclination of the thread to a perpendicular to the axis of the tap), the high temper necessary to prevent wear, and the twisting or torsional strain to which the tap is subjected make this a very delicate tool and one very apt to break unless great care is taken in using it. After some experience you will be able to judge by the feeling while using the tap whether it is cutting freely, or whether, if the cutting is continued the tap will break, and will learn to manage it accordingly.

To tap the hole in this exercise, be very careful as you approach the bottom of the hole, not to allow the tap to touch; if it does, the slightest turn farther will break it.

To tap the hole proceed as follows: Hold the tap in the little adjustable wrench provided for **Exercise 27.** small taps, and with the tail-centre in **Tapping.** the end of the wrench hold it up to the tail-centre in the same manner as in the drilling exercise, except that no pressure must be put on the tap, the object being only to guide it and keep it horizontal. Allow the tap to play a little in the centre. Turn the tap back occasionally (by unscrewing it a little) to free it

from the cuttings and dirt, and it will cut better and will not be so apt to break. Follow up the tap with the tail-centre as it is fed in, and when it has been run in very nearly to the bottom of the hole it may be backed out, wiped off, and put away.

Mark out and drill the hole for the wire. First, mark with the tool a ring *aa* round the middle of

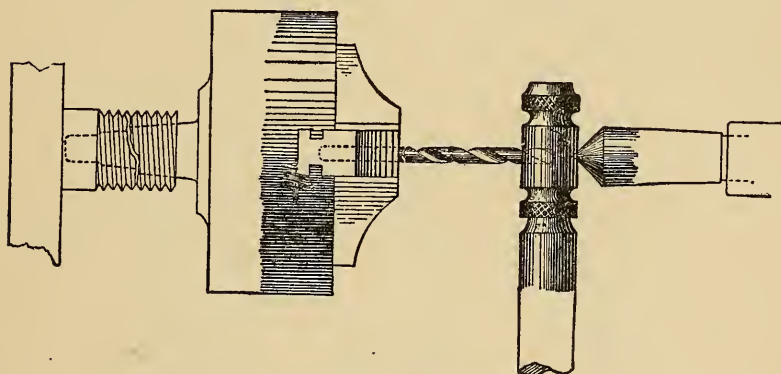


FIG. 53.

the post dividing it into two equal parts, before taking it out of the chuck. With a centre-punch mark two centres exactly opposite each other, one for the drill and one for the tail-centre. Remove the chuck from the lathe and also the work from the chuck. With the proper-sized drill fastened in the drill-chuck and with the chuck inserted in the hole of the lathe-spindle hold the work up to the tail-centre, with the point of the drill in one centre-punch mark and the tail-centre in the

other. Push the drill in very carefully about half-way through, then reverse it, and with the hole now held up to the tail-centre and the punch-mark placed accurately to the point of the drill cut through, meeting the first hole. At this point great care must be taken to avoid breaking the drill, as it has a tendency to feed itself in. It must be held back at this point of the drilling, rather than pushed forward.

Before cutting off and finishing the binding-post grip it again in the lathe-chuck, with the ends reversed, and centre, turn, and finish the screw.

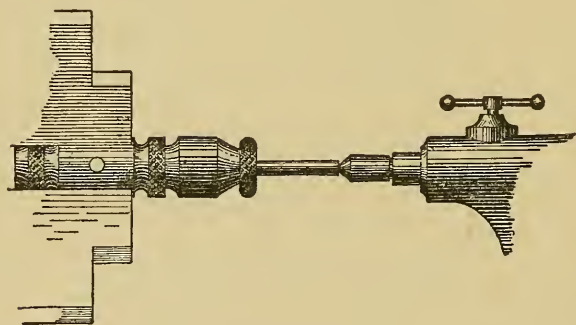


FIG. 54.

To turn the screw and cut the thread, first turn the head to the proper form and dimensions. Rough out the end for the screw-blank to within $\frac{1}{8}$ " of the size of the tap, and while the work is between centre and chuck, Fig. 54, mill the head with the knurling-tool, as in the last exercise.

Remove the tail-centre and finish the blank for the screw-thread, which should be no larger, but rather smaller, if anything, than the size of the tap, as the metal enlarges or swells a little in cutting.

Exercise 28.
Threading.
Use of the
"stock and
die."

The thread is cut with a tool called a stock and die, the stock being simply a holder serving the same purpose as the wrench does for the tap. The die in this case is a small disk made of steel about $\frac{3}{4}$ " in diameter and $\frac{3}{8}$ " thick (shown, enlarged, in Fig. 55). The steel is first annealed

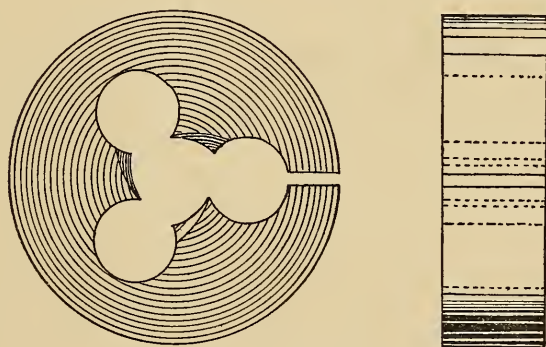


FIG. 55.

and a tapping-hole drilled through its centre. It is then chamfered and tapped, very much as in the binding-post exercise, except that a hob or master tap, as it is often called, is used instead of the regular tap. The hob is a much stronger tool. The teeth are not backed off, as in the tap, but more grooves are cut along the axis of the tool. There are no standard sizes and no

uniformity of pitch, as in the taps. Some hobs with a large diameter have a fine pitch, and some have no screw at all, but simply a series of rings. Hobs are special tools, and are used only for making tools, such as dies, chasers, etc.

After the disk has been tapped, three or four holes are drilled very close to the thread and the metal between them and the central hole removed with a file to form the cutting edges. To file up the cutting edges properly, so that each one shall do its share of the work, requires much skill and thought. One edge must be filed back, as in the tap, to give clearance, and also to prevent the teeth from breaking off while unscrewing the die, and the other edge is filed up to form the teeth. It should also be filed so that the die can start square and so make a true thread. To do this the cutting edges are made to follow one after the other, each one cutting a little deeper than the one which preceded it. This should be done by filing away all the fractional part of the first thread so that the cutting face is one full thread; careful examination of the dies in the shop will make this clear. Some dies are so poorly cut and filed that instead of cutting the metal smooth and clean they press it out, making a very weak thread, "drunken," or not straight, and often strip the thread off, leaving a blank of the diameter of the core or bottom of the thread on the tap.

Dies for general use are made in two halves or parts and fitted so as to slide together in a stock, but the die for this exercise is a small disk filed or milled half-way through (Fig. 56), so that it may be adjusted to cut a screw slightly larger or smaller than the tap, and the screw may thus be made to fit the tapped hole tight or loose. This is done by springing the die by means of three small screws in the stock, Fig. 56.

To cut the thread, open the die about as far as the stock will allow by turning the screw *A* toward the right and *B* and *C* toward the left. Hold the die up to the end of the work and turn it towards the right, holding and leading it as straight as possible. Use the same care as in tapping, to bring the die up to the head of the screw very cautiously and without touching it, as otherwise you are likely to break off the screw, strip the thread, or crack the die. Remove the die by unscrewing it and try

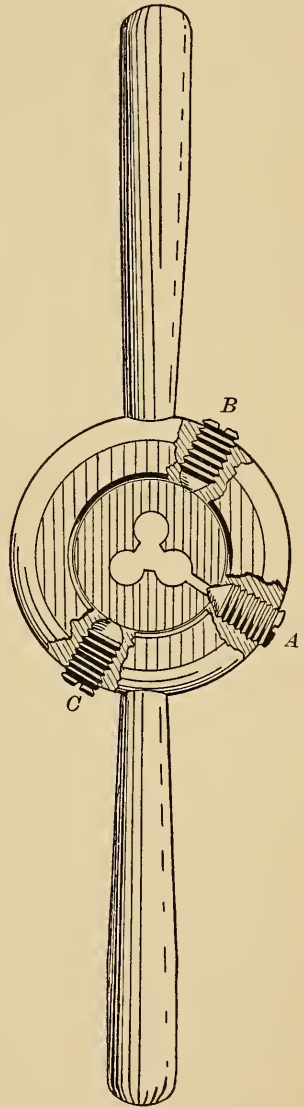


FIG 56.

the tapped piece of brass or a little brass nut tapped for the purpose and to be used as a gauge, and if it is too tight, spring the ends of the die together by unscrewing first the adjusting-screw *A* (turning it towards the left) and turning the screws *B* and *C* toward the right, which will press or contract the die, causing it to cut deeper the second time it is run over the thread. The points of the screws are conical and the die is pierced to receive them, so that to expand or open the die it is only necessary to unscrew the adjusting-screws *B* and *C* and to turn the screw *A* in, thus forcing the conical point forward between the two parts of the die and opening it.

Take a sufficient number of cuts over the screw-blank to fit the screw to the gauge easy without shake. Cut off the screw with the parting or square-nosed tool and finish the binding-post to the proper length before removing it from the chuck.

Grip the screw lightly in the chuck, protecting the thread with paper, or, better, screw the head well up into the binding-post or nut, fasten the latter true in the chuck, and with the graver and emery-paper finish it smooth.

To make a duplicate of the binding-post from an end-piece of brass left over, first face off the ends to the proper length, centre, drill, and tap, as in the last exercise. Then remove the brass from

the chuck and replace it by a piece of soft-steel wire having about the same diameter as the tap or binding-screw. True up the end and file it to the exact size if it is too large. Thread $\frac{1}{2}$ " of the length of the wire and screw the piece of brass on it, but only so far that the end of the wire shall not project, but shall remain about $\frac{1}{4}$ " inside of the brass, leaving room for the point of the tail-centre. You will find in this exercise that without the tail-centre inserted in the hole of the brass as described it would not be practicable to turn it. Attempt to turn it and you will find it impossible, and will thus impress on your mind the principle already learned in the previous exercises, that to protect the lathe and to do accurate work the

Exercise 29.
Use of chaser.
Threading
with the
chaser.

tail-centre must certainly be used whenever it is possible to do so. Bring up the tail-centre and finish as you did in the last exercise, with the centre in the hole of the brass. With a piece of $\frac{1}{2}$ " round brass $2\frac{1}{2}$ " long, mounted in the chuck, centre, face and chamfer the end with the graver-tool. It will not be necessary in the first lesson to true or turn off any of the metal with the graver, as, if accurately centred, it will be quite true enough for practice-work with the chaser-tools. The object in not turning it true at first is to save time and material.

Now try to cut a thread over it, one inch long.

The chaser-tool is held up to the work in about the same manner as the first tool in brass-work for roughing and turning the metal. Grasping the handle in your right hand with the knuckles under, and not on top, hold the tool down firmly to the rest, and in a horizontal position, with the left hand. Adjust the T so that the top or face of the cutting edge shall be on a line with the axis of the lathe-centres when it is held in this horizontal position. Now with the first and second fingers round the socket of the T or rest and the thumb pressing down on top, give the handle a circular movement, the point directly under the thumb serving as a pivot. The movement, with the exception of the twisting and raising of the handle, is very much the same as the circular movement given to the graver-tool.

To start the thread, commence first at the very end, holding the tool as just described (horizontal) up to the end of the work, and with this circular movement, and only a little sliding movement or even none, use the tool as if it were pivoted on the T rest. Cut a screw with the middle part of the chaser (an expert will cut this first thread with the graver). With a true track for the thread started at the end it will not be difficult to lead off the first trail for the thread straight and true, as the pitch of the chaser will trace its own track. Avoid (as you are now giving the tool a sliding

motion parallel to the axis of the lathe) sliding the tool too quickly. If the track for the thread be coarser than the pitch on the chaser too much sliding motion has been given to the tool, and the reverse is, of course, true if the pitch is finer.

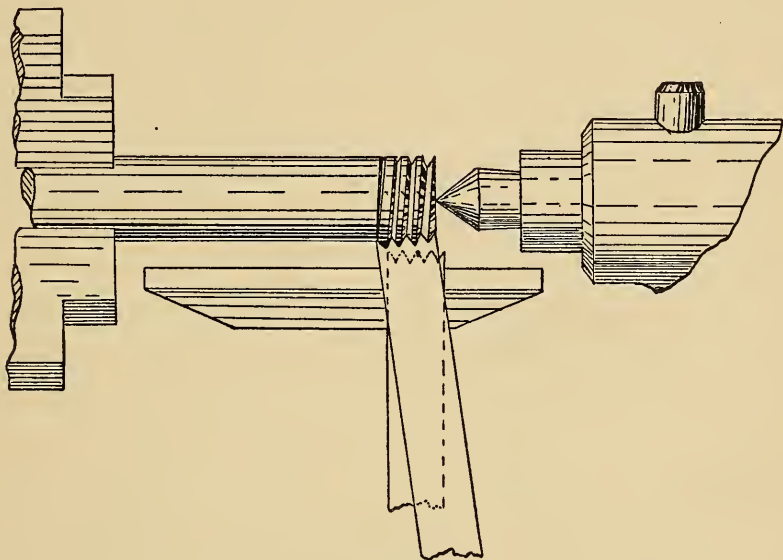


FIG. 57.

The left-handed screw shown in Fig. 57 would be more difficult to cut than a right-handed one. The cutting would begin near the chuck, and with the corner of the chaser instead of the middle.

If you find it difficult to master this uniform sliding motion, which is necessary in order to cut a straight thread, or if the thread is drunken, fasten in the chuck a piece of $\frac{3}{8}$ " round iron threaded at one end and practice, allowing the

chaser to trail along on the thread, and as the tool is carried along on the rest observe the sliding motion and try to give the same motion to the tool when applying it to your work.

Cut over with the tool (keeping in the same trail) as often as it is necessary to cut it to the required depth. The proper depth has been reached when the top of the thread is sharp.

To turn and fit a thread to a standard $\frac{3}{8}$ " use
Exercise 30. the same piece of brass. Turn off the
 Cutting a piece to the diameter of the tap and
 standard to the length proposed.
 thread.

Turn it with the point of the graver and finish in the same manner as in Exercise 28. Cut a thread on this with the chaser, to fit the thread in the nut, so that it can be screwed on easily by hand. To withdraw the chaser at the end of each cut without touching the shoulder or injuring the thread will require skill, which you will acquire by practice.

To cut a thread with an inside chaser fasten in the chuck the disk or piece of brass intended for a
 nut, face and centre it, and drill a $\frac{3}{8}$ "
Exercise 31. tapping-hole through it. Chamfer and
 Cutting an in- side thread. round off the corner with the graver.

To start a true thread on this corner use the chaser in very much the same manner as you would a scraper or a file. To round off the corner with a file you will first hold the file at an angle and

then gradually bring it round till it becomes parallel with the axis of the work. This motion, if properly performed with the chaser, will trace a thread on the corner. Then, with the chaser supported upon the hand-rest and the cutting edge or teeth held parallel to the inside diameter of the hole, trace and finish the thread.

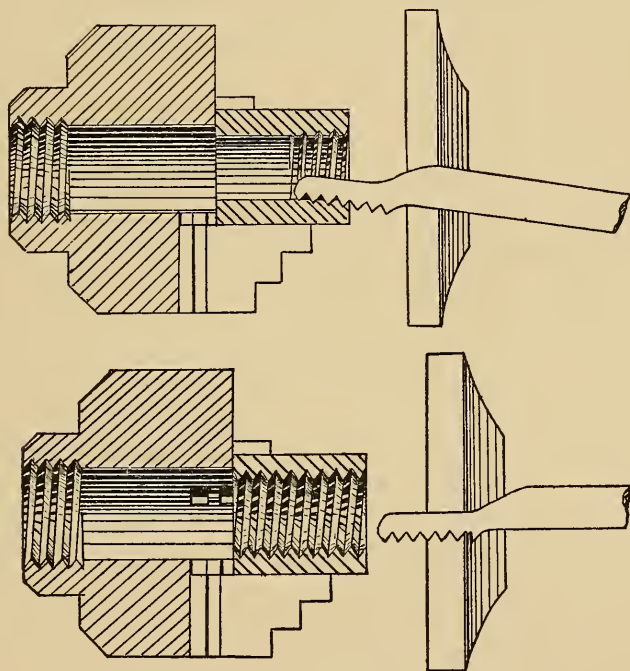


FIG. 58.

Use the same precaution in tracing the first cut for the thread as you did with the outside chaser. Hold the tool up to and inside the hole, touching it, and with the thumb of the left hand draw the tool up and slide it along carefully with both hands. Fit it to the screw turned in the last exercise.

Turn another screw as in Exercise 29, and before cutting it off screw on the brass nut (Exercise 31) and, using the screw as a mandrel, mill and finish the nut.

To turn and fit a cylinder or plug by means of inside and outside gauges, a method called a “cut-and-try” fit, you must be provided with

Exercise 32. a cylinder fitting exactly in a cylindrical hole. Set the outside calipers to the cylinder or plug and turn your work down till it is as near the size of the duplicate or gauge as you can measure with the calipers. Try the work in the hollow cylinder and turn off and try again until an easy

Use of inside and outside calipers.

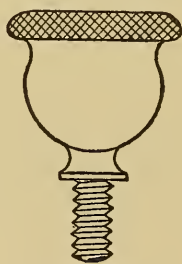


FIG. 59.

fit without shake is obtained. Then cut off and recentre. Having fitted one cylinder to the hole in the disk by repeated trials, fit another one without trying the two pieces before they are finished, depending only upon calipers for the fit. The accuracy of your work will depend very much on the manner of holding the calipers while setting

them and while applying them to the work after they are set. Read the lesson in Engine-lathe Work on fitting with calipers. Finish and mill the head or disk like the pattern.

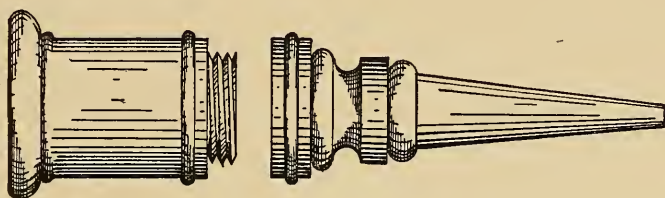


FIG. 60.

For additional exercise make an oil-cup, Fig. 59, and a glove-powder box, Fig. 60. These exercises involve no new principles, and are not necessary except for practice. Use the common flat tool or the graver-tool in this exercise, as in heavy brass-work or in steel- and iron-work. Hold the knuckles below, the forefinger grasping the T, and the other fingers the socket, as already explained.

Exercise 33.
Practice-work with the graver and gouge.

Other exercises which will afford practice with the gouge on both inside and outside work are shown in Fig. 61.

LESSON VIII.

WOOD-TURNING. GOUGE-WORK.

OUR wood-turning exercises hitherto, including even those on which concave surfaces have been formed, as in the case of the file-handle (Fig. 18, page 30), have been performed with the chisel. There were two reasons for thus deferring the introduction of the gouge: first, it is a dangerous tool in the hands of a beginner, and even in those of

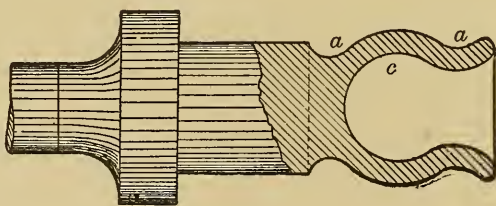


FIG. 61.

an expert, unless it is handled very carefully; and secondly, when the chisel is thoroughly mastered much work can be done with it for which the gouge would otherwise be used, and thus time can be saved. It is now, however, necessary to learn to use the gouge. For this purpose we will turn a box or

cup, shown in Fig. 61. This is very much like Exercise 13, page 37, and might be performed with the chisel, though imperfectly and with more difficulty than that exercise, because of the undercutting at *c*.

Rough out between centres, as in the egg-cup exercise, using the large and small gouge to rough out the exterior, and leaving a little to finish up after the inside has been finished, as in the first lessons.

Exercise 34.

A cup.

Use of the gouge.

One of the mistakes oftenest made in using the gouge is to attempt to cut *up* an incline. Always cut *downwards*, and turn the concave part of the



FIG. 62.

gouge away from the surface you are cutting. Finish the moulding *aa* and all you can of the outside first, and then proceed to face and bore.

To face and bore, the position of the T is to remain just as it would be for outside work,

especially if the cavity to be cut is a shallow one; if deep, the T should be moved a little obliquely, but not at right angles to the axis of the lathe, as for other tools used in boring. Now if the gouge is properly ground and has but one slope *ab*, place it on the T with the hollow inclined to the length of the T, and with the bevelled face bearing flat against the end of the piece, which has been already faced off square and true. In this position the gouge of course cannot cut. Still holding the gouge thus, move it up or down,

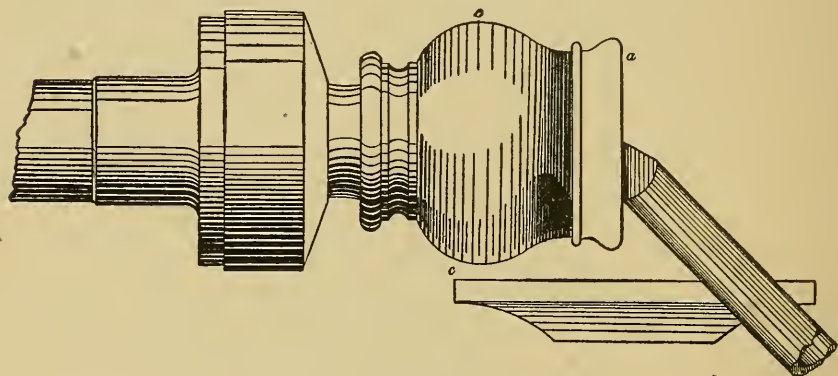


FIG. 63.

so as to bring the cutting edge or point *a* to the centre of the work. It will still refuse to cut. Now swing the handle of the tool just a little toward your right, still keeping the point or cutting edge *a* at the centre and still holding the concave face towards the right. This movement will cause the heel *b* to move a little from the surface, and the point *a* to penetrate or dip in, cutting a

small cavity in the face. Now to cut deeper the tool must be pushed in and over still a little farther away from the centre, cutting on the farther side rather than on the side of the centre nearest you. This will perhaps become clear to you if you stop your lathe and use the gouge as you would a carving-tool. This will give it about the movement and the position it should have on the rest. You would in this case naturally grasp the handle of the tool in your right hand and the blade in your left, and push the gouge a little from you, gradually raising the point or edge *a* (Fig. 63) and turning or twisting the tool over and round toward the right, till the concave part of the tool should lie almost flat on the T, having made a quarter turn. If the work had been revolving at the time instead of being at rest a cavity would have been cut all round the face, and not only one quarter of the way round, as would have happened if the work were at rest. Start the lathe running and repeat this, pushing the gouge ahead, raising the cutting edge and twisting the handle, and compelling the tool to cut on the side farthest away from you, repeating the operation until the proper depth has been reached. It may be necessary to move the T round obliquely in order to finish this exercise. Deep holes cannot be cut with the gouge; a hole can be bored, but it cannot so easily be enlarged.

First turn a true cylinder having the diameter of the intended ball. With a parting-tool turn down a quarter of an inch at the right-hand end to the diameter of $\frac{1}{4}$ ". Be-
Exercise 35. ginning at the same end, lay off two
Turning a distances cb and ba equal to half the diameter
ball by hand. of the ball, and at the three points thus set off mark lines round the circumference with a fine

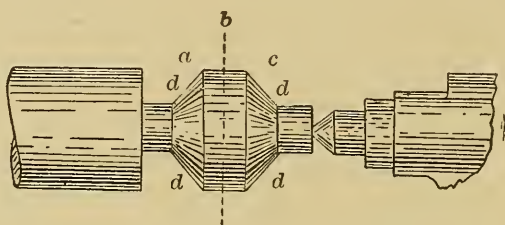


FIG. 64.

lead-pencil or the acute angle of the chisel. Sink the parting-tool in at a and c (leaving part of the line if possible) to a diameter of $\frac{3}{8}$ " or so. The faces thus formed should be parallel and the distance between them equal to the diameter of the ball, the line b being exactly midway between the faces. Before cutting any deeper with the parting-tool chamfer the ends off till, tested with the calipers, the work measures the same across ac , ac , bb , and dd . Then cut off and chuck the partly turned ball, with the line bb a little outside of the chuck, Fig. 65, and running perfectly true. One half of the ball can now be finished.

Rough out the exterior first with the small gouge and finish with the chisel or other scraping-tool, cutting away half the breadth of the line *bb*. As the ball is to be of a standard size, apply to it the

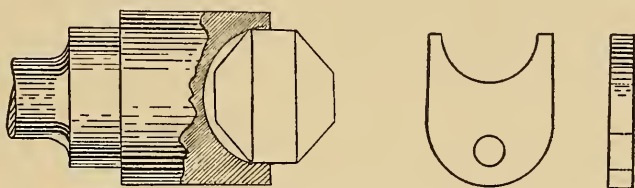


FIG. 65.

gauge, Fig. 65, a piece of sheet brass about $\frac{1}{16}$ " thick. Several such gauges are kept on hand to be used for this purpose, and sometimes a plate or block of metal, Fig. 66, with a series of

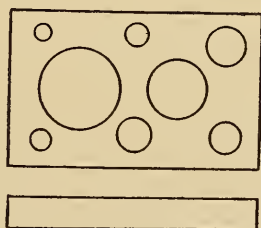


FIG. 66.

holes accurately turned in it to test finished balls. Having turned one half the ball true to gauge, remove the chuck, push out the ball, and make another chuck to receive and hold the finished part which has just been turned. Hollow out this second chuck so that the half ball will go into it far enough to hold tightly, allowing the

angles to be turned off, the line *b* remaining outside a little distance from the face of the chuck, in which it should be carefully set as before. Turn this outer half in the same manner. The work must gauge precisely the same at all points. Test with calipers and gauge, including the ring-plate if you have one, and mark with a pencil or with the gauges themselves any little protuberances found. These protuberances can all be removed very quickly between female centres or blocks, Fig. 67, having in each a small cavity or hollow

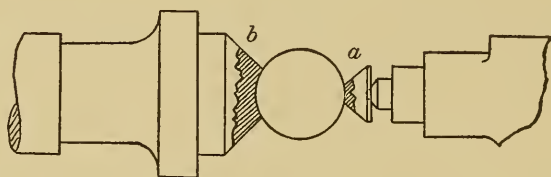


FIG. 67.

turned to receive the ball. The chuck-block *b* is made fast to the face-plate, while the block *a* is loose and held up to the ball by the dead-centre; this block or centre should be perfectly true, so that the ball can be moved from one desired position to another and always revolve concentrically. This is very slow work, and not so accurate as with a lathe having special attachments for the purpose, such as spherical slide-rests, etc., and it requires much more skill.

Metal balls, used as valves in some pumps, are

often turned and fitted to their seats by hand. To save time the balls are cast two or more on a stem, so that they can be roughed out to size and shape between the centres, after which they are nicked and cut off with a metal-saw, or if the nick is midway between two balls, as at *a*, they can be broken off and the projections filed off to fit the gauge.

The chucks are then prepared to fit the partly finished balls, as in the last exercise, and the balls are turned and finished in the same way as the

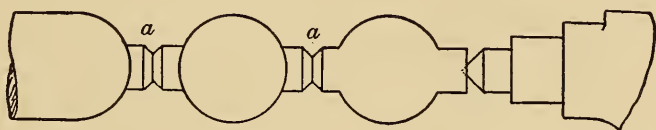


FIG. 68.

wooden ball. The ball, which should have been turned very close to the form of the gauge and set of calipers, is now chucked either in a chuck with a hollow large and deep enough to receive about one half of the ball and hold it firmly, or between the shallow chuck and female centre, as described in the last exercise. Now with a keenly sharpened tool cut a little flat ring of a diameter exactly equal to that of the ball. Turn the ball so that the plane of the ring shall pass through the axis of the lathe, and turn another band or ring at right angles to the first, cutting down till it just touches

the first ring. By thus turning the ball round a few times in the chuck, so that the marks shall cross and recross each other, cutting as many as convenient, it will be easy to finish entirely by hand, without the assistance of the ball-cutter, a perfectly true ball, so that when it is ground to its seat with glass, sand, or burnt foundry-sand, and oil, it will be absolutely tight.

LESSON IX.

OVAL TURNING.

WHEN two head- and tail-stocks from lathes of the same size are mounted together temporarily on one bed by means of a plate made for the purpose, and with a long drum or overhead gear, as it is called, of the same length as the bed, the machine thus produced is a "double-header," Fig. 69. It will have two cones and two dead-spindles. This allows you to place any piece of work between one pair of centres without disturbing that mounted in the other. Different speeds also can be obtained, comparatively slow in one and fast in the other, one mandrel or centre revolving say at 25 and the other at 250 revolutions per minute, and both turning in the same direction or, if one belt is crossed, in opposite directions.

The work to be turned is, of course, mounted between the front-centres. The tool may be a rapidly revolving disk *b*, carrying one or several cutters, and driven by the overhead drum. The shape or form of the cutters is made to suit the special kind of work. The disk is carried in a slide moving in and out, to and from the centre,

perpendicularly to the axis of the lathe. The cutter is pulled up toward the centre by a weight or spiral spring, and moved along the bed by a screw or lever. Now the pattern of an axe-

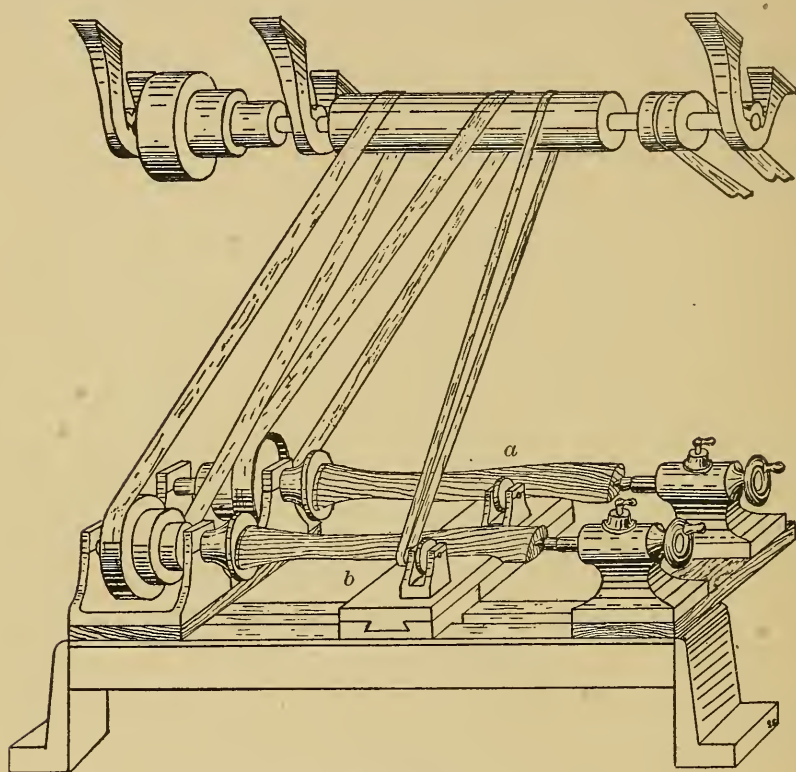


FIG. 69.

handle or any oval piece of work is mounted between the back-centres and the proper speed given to it, which in this case must be the same as that of the work to be turned.

The two mandrels, one driving the pattern and one the work to be turned, are revolved. A pulley *a*, having the same diameter and form as

the cutter *b*, is fastened to the slide, and is held in contact with the pattern by a weight or spring, not shown in the figure. As this oval pattern revolves, it pushes the slide and the cutter out and further away from the centre, and as it continues to revolve the weight or spring draws the slide back toward the centre again. The pulley is thus kept close to and bearing against the pattern, and if the cutting edge of the cutter or disk and the form and circumference of the pulley are the same, an exact copy of the pattern will be produced. It is easy

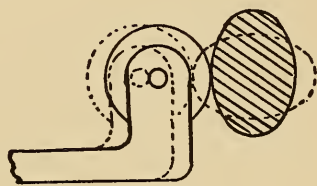


FIG. 70.

to see that the common lathe can thus be made to do many kinds of work. An "index-plate," a pair of extra centres adjustable as to height and angle with the lathe-bed, and other attachments are now found permanently fixed on beds of lathes or machines designated and sold by special names.

With such machines the workman is valued not so much for the amount and accuracy of the work accomplished, as for his ability to invent, design, and set up his tools, as will be seen later in the study of engine-lathe work.

LESSON X.

METAL-SPINNING AND BURNISHING.

METAL-SPINNING and burnishing can be done on the hand-lathe without the use of other attachments; all that is needed is the T, necessary chucks, mandrels, and the ordinary hand-tools, tilting-rest and compound rest. For this work the lathe should make about 800 or more revolutions per minute.

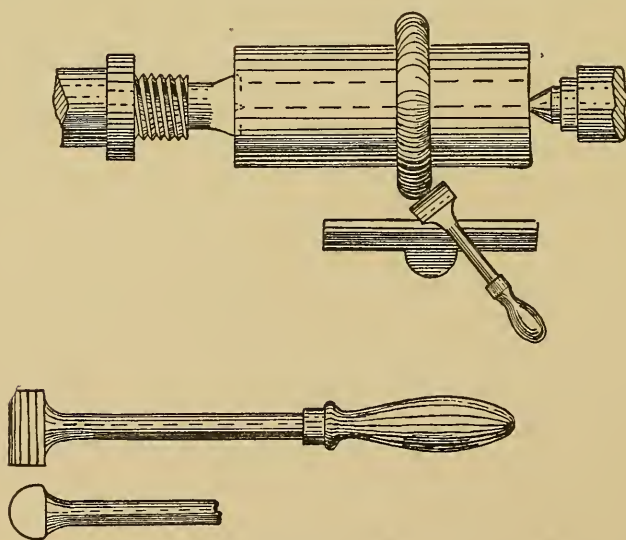


FIG. 71.

To burnish a piece of work is to polish or give a gloss to the surface, and it is done by holding up to the work a burnisher, a tool with a small, bright surface, generally rounded at the end. The tool must be made very hard and kept cool. To burnish a piece of work, a ring, for **Exercise 37.** instance, Fig. 71, the work must first **Burnishing.** be finished smooth, and all the scratches removed with files, emery, and oil. The tool is then applied by holding it in the rest and pressing it against the work as it revolves at a high speed. This gives that high polish to the surface that is found in highly finished silver- and steel-work.

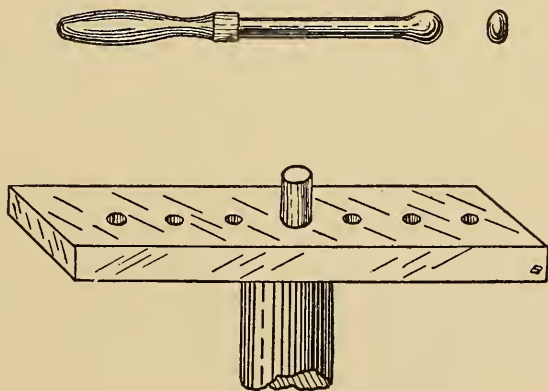


FIG. 72.

Spinning is very interesting work and is almost a business in itself. To spin metal, the speed must be high and the metal thin and properly annealed. A rest with a long T is required, with a number

of holes for the insertion of the steel pin which is to serve as a fulcrum for the tool. But little skill is required in spinning, compared with that demanded by other kinds of lathe-work. The effect required is produced by pressing against the metal with a smooth tool free from all sharp corners. For ordinary use the most convenient tool is the one shown in Fig. 72, having an elliptical cross-section; but sometimes several different tools are used in one piece of work.

Try as an exercise to spin a common bowl or any concave vessel. First a disk of metal is cut of the

Exercise 38. proper diameter and a mould turned
Spinning. A of the required form (Fig. 73) and
 metal cup. fastened to the face-plate. The disk
 is placed between the mould and a cylindrical
 piece of wood, and held in position by the centre.

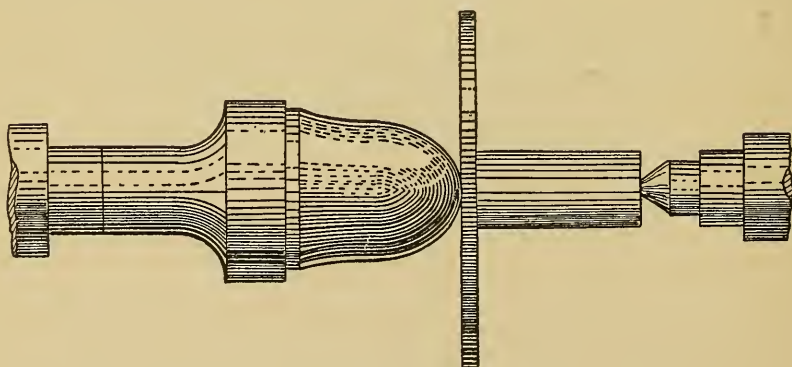


FIG. 73.

The mould is often hollowed a little on its face to make it hold better. First centre the disk

by holding the tool or a piece of wood on the T with the end bearing up against the lower edge of the metal, Fig. 74. Press gently as you turn

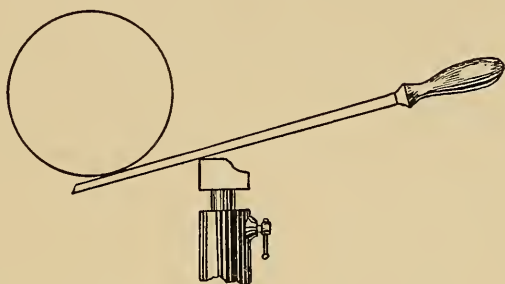


FIG. 74.

the work by hand, and, the pressure between the head-stock and the metal being released, a few revolutions will cause the work to revolve concentrically. Now, with the disk properly chucked, and a speed which will generally be the highest that can be obtained on the ordinary lathe, place the steel pin in one of the several holes that will bring the tool about at right angles to the lathe-bed when held ready for work. Holding the centring-tool, made of wood, in the left hand and the tool of steel in the right, place them both on the rest, with the disk between them. Now bring a gentle pressure to bear against the metal, near the centre first, and if you give it time you will cause the metal to conform perfectly to the mould, but if you force it too rapidly the metal will crack. The object in using the wooden tool is to prevent

this cracking or buckling and to steady the plate and the tool. If the work buckles and cracks the speed probably is not high enough. It is this high speed and a light pressure, such as would produce a slight indentation if the lathe were at rest and a series of circles when revolving, that will enable you to draw out and mould the metal into any de-

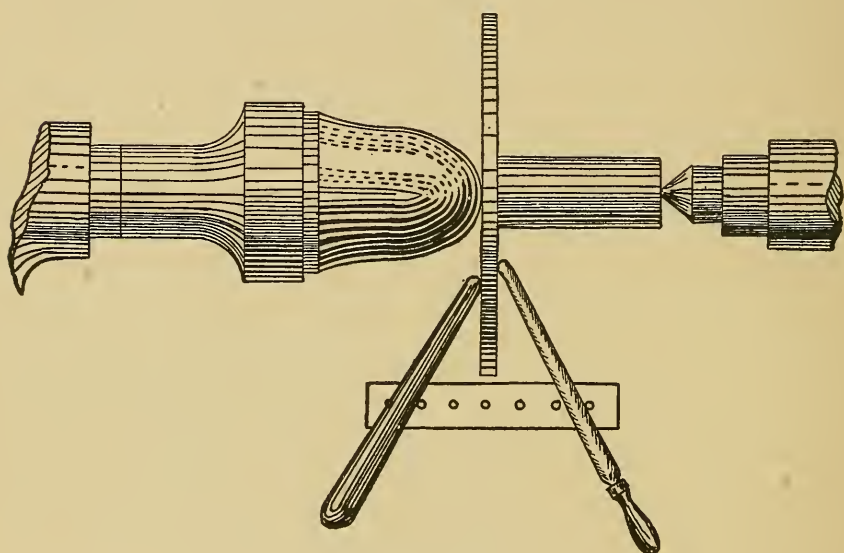


FIG. 75.

sired shape; an expert after spinning a piece of work like this can spin it back again to its original form, a disk. Spinning is usually done dry, although in some cases soap-suds are used. Press-work or stamping is taking the place of spinning to some extent, particularly in sheet-brass work, when large quantities are ordered. White metal is mostly spun at present, as it cannot so easily be

pressed out in dies with a press. Though it is very flexible and can be spun nicely, it needs more "coaching" and time than sheet brass, and when stamped is likely to tear under the great pressure, while sheet brass, if annealed, does not.

The spinner, like the pattern-maker and the lathe-hand, is supposed to know how to design and make all his tools, moulds, etc. Some of the moulds used for spinning fancy oil-cans, sugar-bowls, teapots, and some of the large work spun for locomotive and marine engines require much thought and skill; the moulds, instead of being solid, are in sections and would puzzle an inexperienced workman to put them together.

LESSON XI.

SPECIAL TOOLS AND APPLIANCES.

You have found that it takes a considerable time to turn an oil-plug, a binding-post, or any exercise which requires a considerable number of operations. If a great number of such pieces were required quickly a sample would first be made by hand, and then special tools would be designed, to be used in an appropriate machine. Such machines are the screw-cutter, the tapping-machine, the milling-machine in its different forms, the gear-cutter, the monitor, the turret-lathe, and many others specially designed for turning out work accurately and in large quantities. If you could see the binding-post turned and finished in the turret-lathe or the screw in the screw-cutter you would find that a very great number can be produced in a short time. These special tools and machines are all very costly, and if a tap, die, or forming-tool should be ruined by cutting a dirty casting or piece of work with iron or steel in its composition, the loss would be considerable.

All castings and brass must therefore be clean, and the finisher must insist upon this. A well-equipped shop will have in connection with it a foundry and all the necessary tools. It will be provided with a separator to separate all the iron and steel chips and filings from the brass. This consists of a vertically revolving magnetic disk, over the edge of which is fastened a band of very thin sheet brass, covering the rear half of the edge. The cuttings from the machines are put in a funnel directly over the slowly revolving disk and allowed to fall on the brass strip, and thence on the magnet. The brass filings and chips are not attracted by the magnet, and as the disk turns they drop off into a receptacle placed to receive them, while all the steel and iron revolves with the magnet, but before making a complete turn is brushed off by brushes which come in close contact with the cylinder. This operation is sometimes repeated.

All castings are washed or cleaned by putting them into a revolving barrel called a tumbler. This barrel is sometimes made of iron, but wood is much better, as the iron sticks to the castings, giving them a bad color. The tumbler should not be entirely closed, and is generally suspended in an inclined position over a tub or sluice with two or three compartments to receive the dirt and water from the barrel. All the sweepings from the floor of

the foundry, the burnt sand, pieces of scrap-iron, and dirt or dust are put into the barrel with the castings. As the barrel revolves, full of water, not only

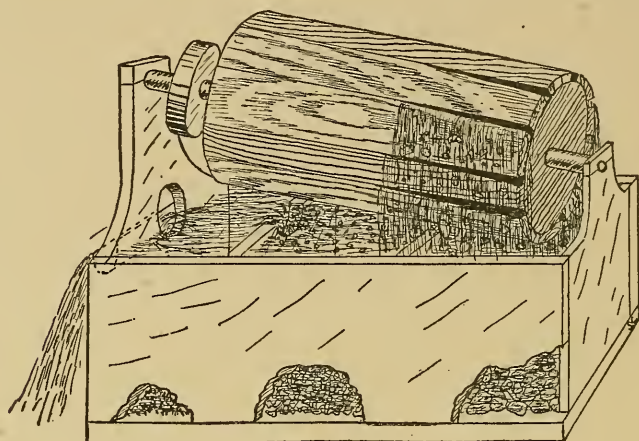


FIG. 76.

are the castings cleaned, but the brass lumps and chips also. The inclination of the tumbler will cause all the pieces to rub together. The dirty water and the pieces of brass that are washed out through the crevices made in the barrel drop into the tub, the heavier pieces in the first compartment, the next lighter in the second, and the lightest in the third, the dirty water flowing on and discharging into the drain; the overflow being at the top of each tub, nothing is lost, and every piece of brass in the sand is found and is perfectly clean. The castings after revolving for a time in this barrel of water, sand, and scrap are clean and fresh-looking and have what is called a good color.

The forming-tools, reamers, taps, and dies, and all special tools used for producing work accurately and quickly, are very expensive.

Exercise 39.

This will readily be seen, for instance, in the case of the forming-tool used

The forming-tool.

for valve, injector, and beer-pump work, Fig. 77. This is a cutting-tool resembling a piece of wide moulding, sometimes 6" or more in width, with the end cut off obliquely instead of square. The

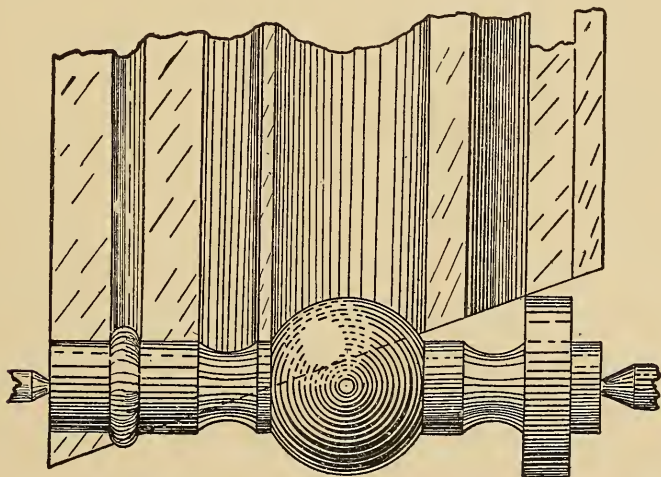


FIG. 77.

stock is first roughed out or cleaned with a common hand-tool. The tool, which is set vertically and at the proper distance from the line of centres and parallel to it, is brought down in the same way as the knife in the shears, cutting first at the acute angle, at the very end of the piece, and gradually along the whole length of the tool,

thus meeting with but little resistance. If this tool were square at the end it would be impossible to cut with it, nor would it be practicable even to use it as a scraper-tool, as it would fill the work full of "chatter"-marks—little cuts like those on milled work. The reason of this is that all broad-faced tools spring away from the work and return to it with a series of vibrations; but with the cutting edge at an angle as just described, properly ground and tempered, it will cut a very smooth surface and a great many such, making them all alike.

With these special tools, emery-wheels, buffers, and rag-wheels, some very fine work in brass is finished by cheap labor, as that of boys or unskilled hands, in a short time. The rag-wheel is made of disks of rags, 12" or more in diameter, fastened to a mandrel and revolving at a speed as high as 4000 revolutions or more per minute, giving a fine polish to the work which is pressed against it.

LESSON XII.

UNDERHAND CUTTING WITH THE GOUGE.

HAVING learned how to do good work by holding the handle of the gouge in your right hand and the blade in your left, with the knuckles on top, which is called "overhand" working, you may now begin using the tool in the following ways:

First. When turning large work, 20" or more in diameter, hold the handle in either the right or the left hand, and press your arm firmly against your side, holding the knuckles of the left hand either above or below the blade.

Second. In turning very small work hold the handle in your right hand and the blade in your left, with the thumb on top and the forefinger under the T, as in Fig. 78.

Third. In small work, either in wood or brass, when the work is hard or angular and it is necessary to hold the blade of the tool very firmly on the T, place the thumb in the concavity of the gouge, the forefinger around the

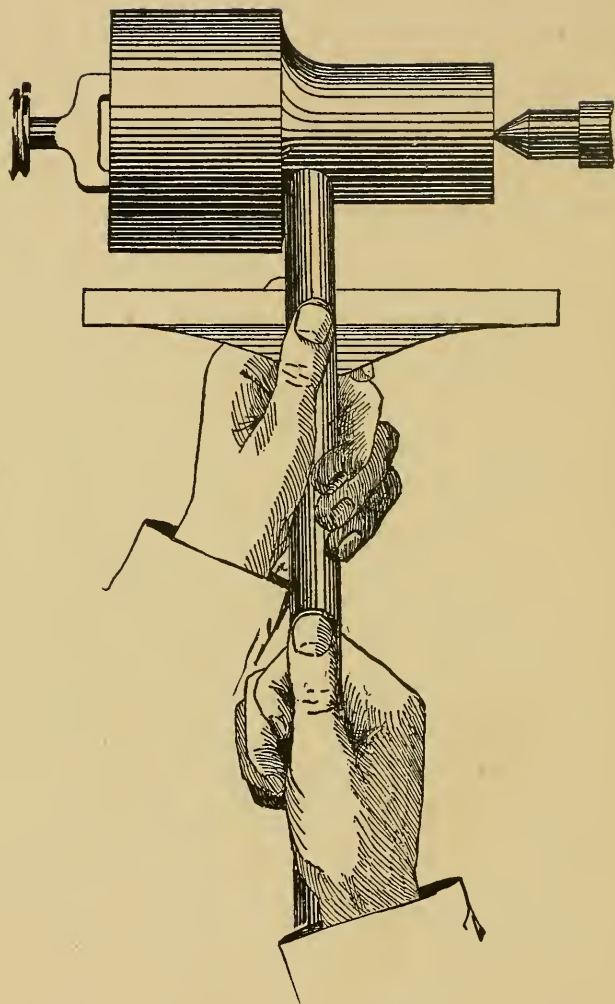


FIG. 78.

T, and the other fingers grasping the socket and the rest, as in Fig. 79.

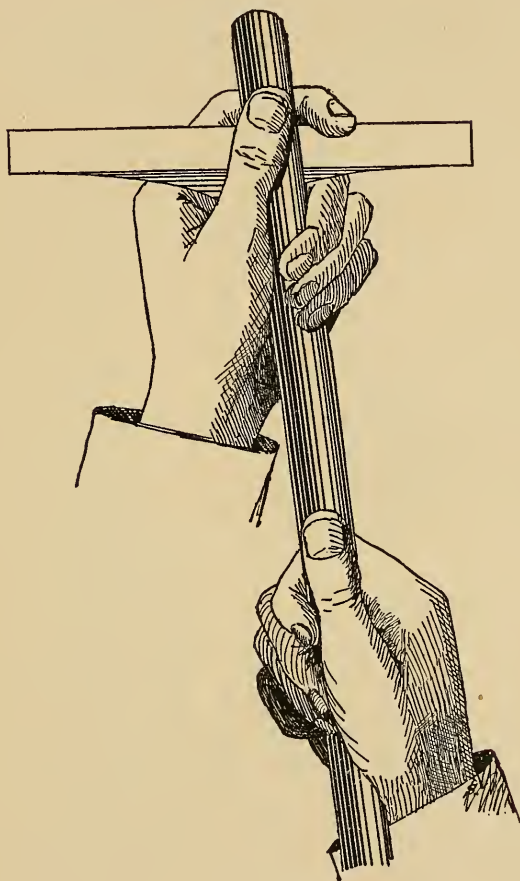


FIG. 79.

Fourth. In turning small work, when it is necessary to use the gouge or calipers frequently, hold the knuckles underneath, as in Fig. 80, so that the tool may drop into a vertical position, out of the way.

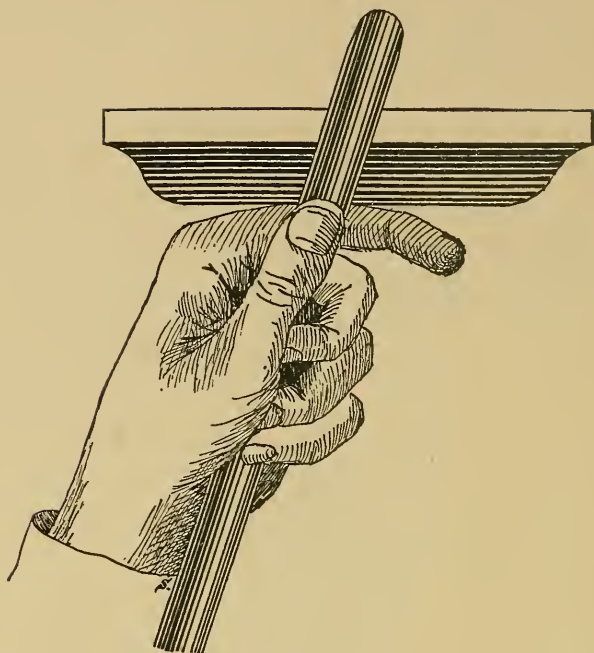


FIG. 80.

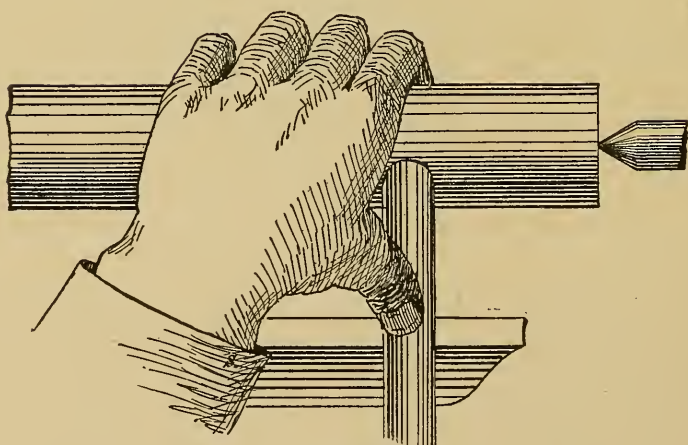


FIG. 81.

Fifth. When using the fingers of the left hand to measure and dismount the work quickly while it is running, place the thumb in the hollow of the blade while the fingers are stretched over and around the revolving work, as in Fig. 81.

Sixth. Work that is fastened on the face-plate or held in the chuck is called face-plate or chuck work. For such work the gouge is held as in Figs. 78-81 to turn the exterior, and as described on pages 91 to 93 to bore, enlarge and finish the inside.

The exercises shown in



FIG. 82.

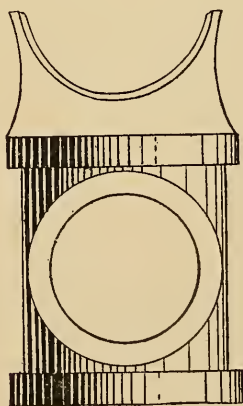
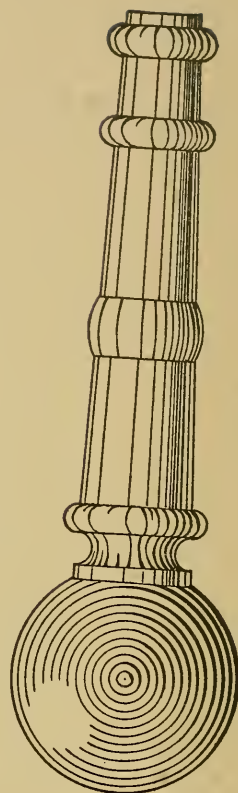
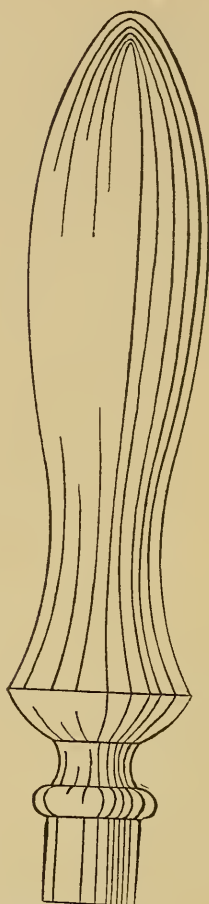


FIG. 83.

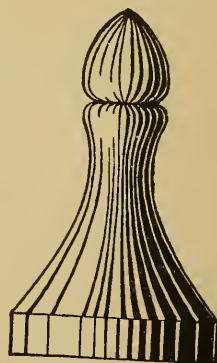
the following figures are suitable for practice in these several ways of working, none of which,



Fancy Handles.



Knobs.



Chessman.

FIG. 84.

however, are to be attempted before you have become skilful in "overhand" turning.

Fig. 82 shows the frame and Fig. 83 the cylinder of a small vertical engine. This is to be turned by the first method, except when the workman prefers to turn it on an engine-lathe.

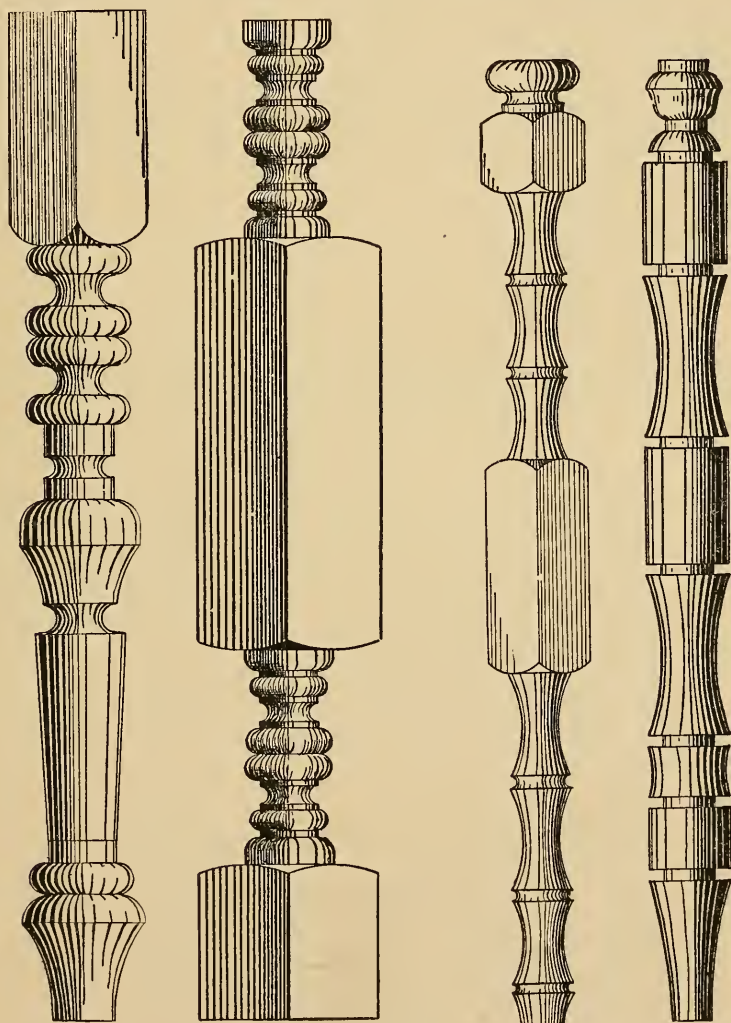


FIG. 85.

FIG. 86.

Figures 84 are suitable for the second method.

Figures 85 illustrate the third case.

The pieces in Fig. 86 are suitable for the fourth method, where the frequent use of the calipers, or of the "sizing-chisel" shown in Fig. 87, is required.

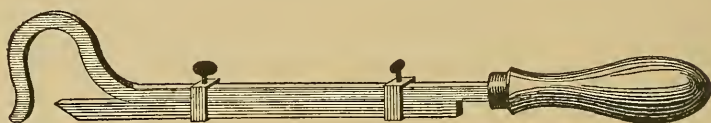


FIG. 87.

Balusters, spindles for cabinet-work, rungs for chairs and tables, such as Fig. 88, when made in

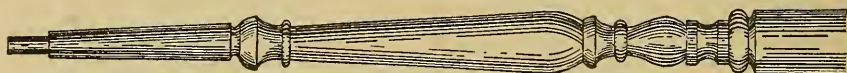


FIG. 88.

large quantities and cheaply, are gauged by the sense of touch and mounted and dismounted without stopping the lathe. They are suitable for the fifth method of working.

Figures 89*a* and 89*b* show objects suitable for the sixth method.



FIG. 89*a*,

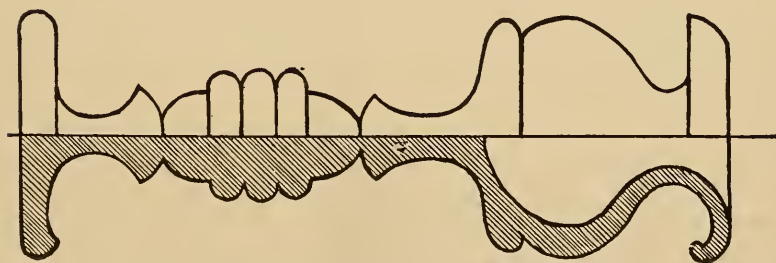
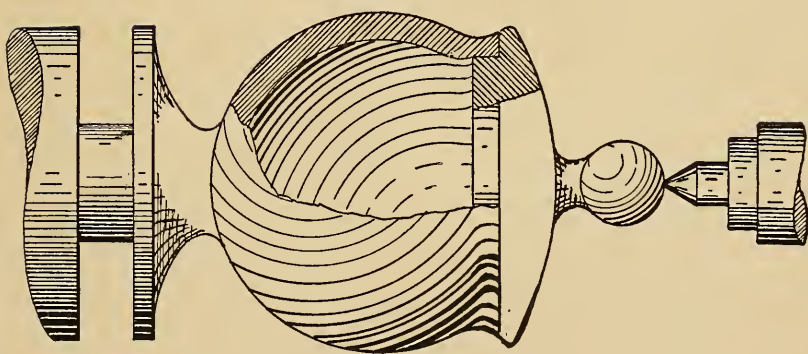
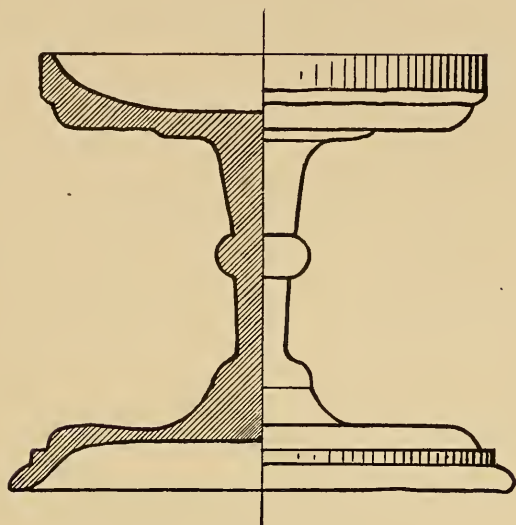
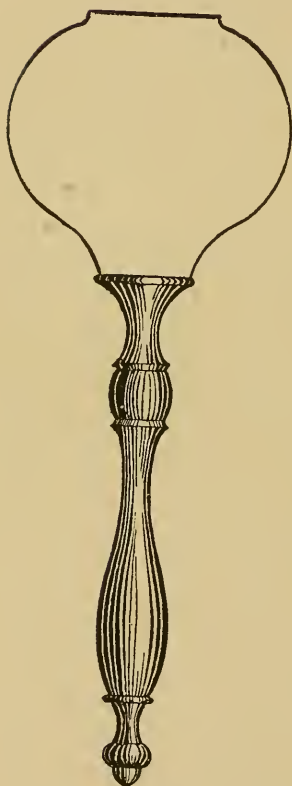
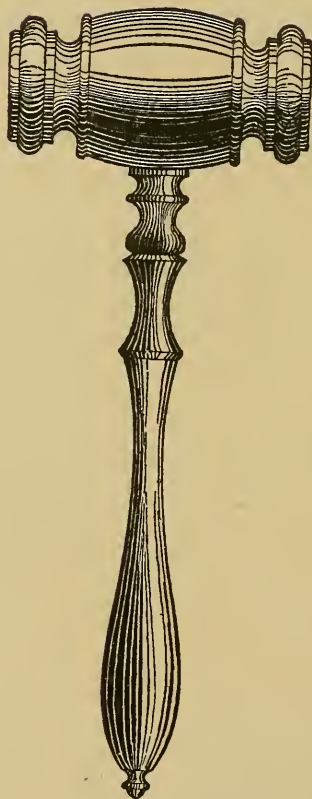


FIG. 89b.

Select your own method of treating the following cases :



Gavel.



Mallet-gavel.
FIG. 90.



Glove-darner.

LESSON XIII.

THE COMPOUND REST.

FIG. 91 represents a slide-rest, with a device *c* for holding the cutting-tool. It is fastened to the bed, like the T rest, by means of a bolt. The depth of cut is adjusted by means of the handle *aa* or *bb*. The slide can be swung around so

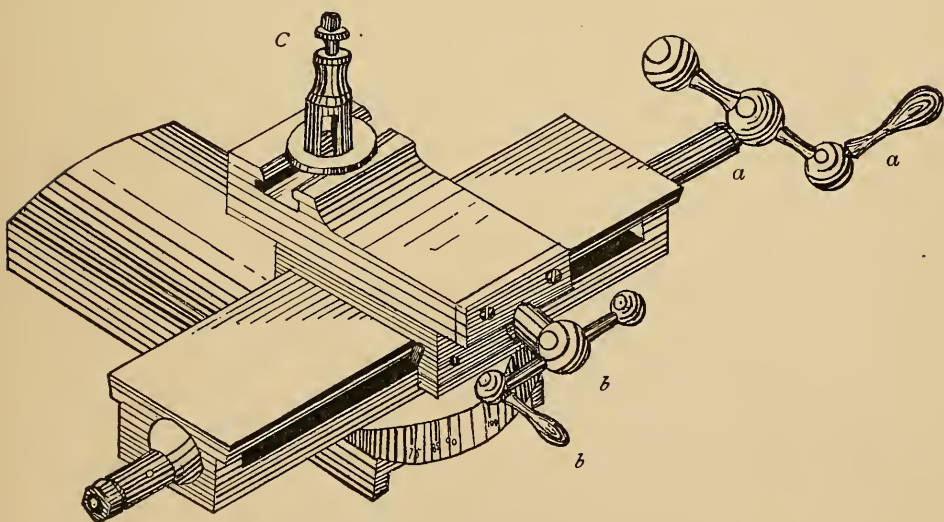


FIG. 91.

that the direction of the cut may be parallel to the length of the shears or at any desired angle with them. It is operated transversely by means

of the screw *b*. A slide-rest of this description is called a compound rest, and is constructed to turn work tapering as well as parallel.

Set the rest to cut parallel with the axis of the lathe, and turn a cylinder, as in Exercise No. 22.

Exercise 40. While the compound rest may be used with the common speed-lathe, it is an essential part of the engine-lathe, and the various operations of turning parallel and tapering, setting, grinding, and operating the tools for slide-rest work are fully described in the chapters on that machine.

To make a miniature Sellers shaft-coupling, Fig. 92, such as may be found on the shafts in many shops, first cut off two pieces of 1" round brass 1" long, chuck, face, centre, and bore a hole through each piece $\frac{7}{16}$ " in diameter. Now replace it with a piece of $\frac{1}{2}$ " round brass rod and, allowing it to protrude

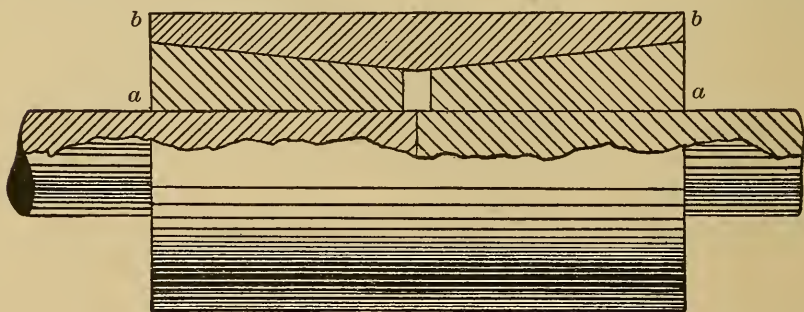


FIG. 92.

from the face of the chuck 3" or more, centre it and turn about 1" of its length to fit the hole in

the cylinder tight. Drive it in gently, and, using the rod as a mandrel, proceed to turn and finish the piece. Set the slide-rest to turn tapering 1" at one end and $\frac{1}{16}$ " at the other. This can be done by first turning the ends to the proper dimensions and setting the slide so that as the tool is moved along from end to end it shall be exactly at the same dis-

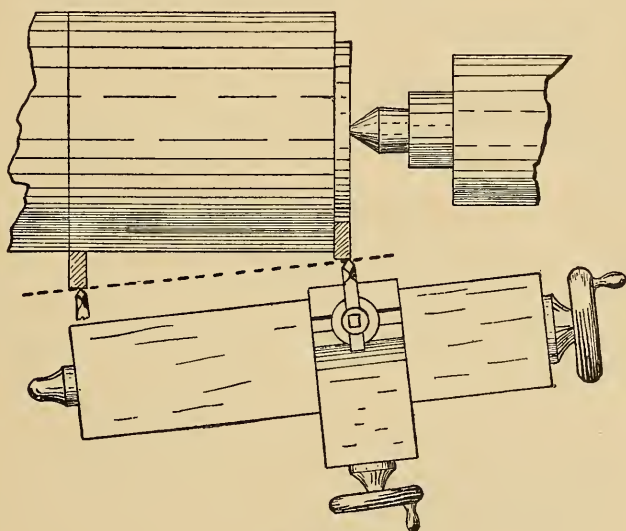


FIG. 93.

tance from the piece at both ends. It can be set approximately by sight, and very exactly by holding a piece of metal which fits closely, first between the point of the tool and the small diameter, and then between the tool and the large diameter. If the piece feels the same at both places the rest may be considered properly set. In cases where the work can be removed from the lathe

and replaced exactly, you can test it very accurately by running the tool up and scraping off a chalk-mark and a little of the metal at one end, and then, without touching the screw or the

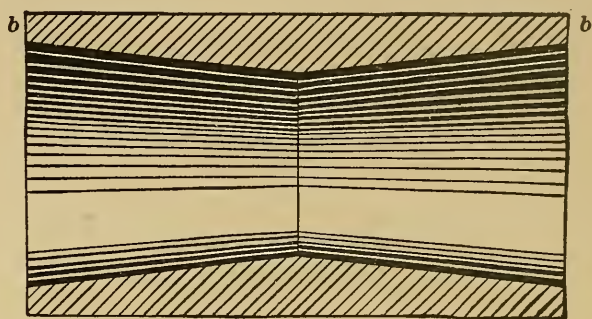


FIG. 94.

handle of the rest, running the tool along to the other end, where it should scrape off the same as at the first.

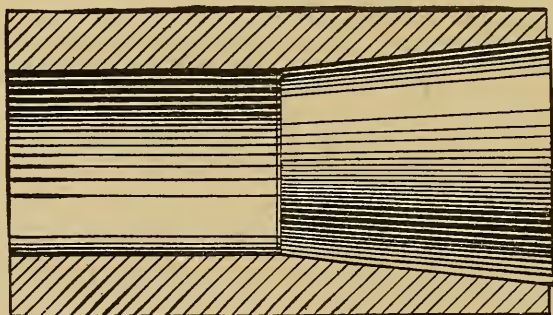


FIG. 95.

Turn the two pieces so that they are alike. Having now finished the cones, *aa*, Fig. 92, turn and fit the shell or ring, *bb*. Chuck a piece of

1 $\frac{1}{4}$ " round brass about 2 $\frac{1}{4}$ " long. Face and centre it and drill a $\frac{1}{4}$ " hole through it. Then enlarge with a $\frac{5}{8}$ " drill. Now with a brass-boring tool bore it true to $\frac{3}{4}$ " diameter. Next bore a recess at the end 1" in diameter and $\frac{1}{4}$ " deep. The chuck for this exercise should be absolutely true, and the ends or face of the work must be pushed back against the face of the chuck. Now set the tool and bore the taper, as shown in Fig. 96,

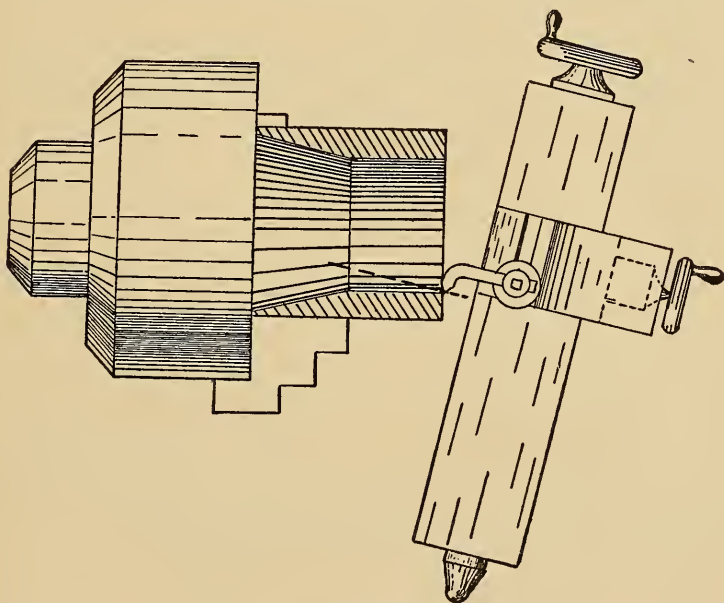


FIG. 96.

boring first one half to fit one of the cones, and then, after reversing the piece in the chuck, boring the other half to fit the second cone. The setting of the rest is accomplished in the same way as for the outside taper. (See Fig. 93.) With the

cones placed in position and fitting snugly in the shell or ring, mark and drill three holes, about $\frac{1}{8}$ " in diameter, to fit a wire of the same size as the binding-post screw-tap. Drill a clearance-hole in one cone and a tapping-hole in the other. Saw with a metal-saw each cone half through, as at *a*, Fig. 97, so that it can be sprung together.

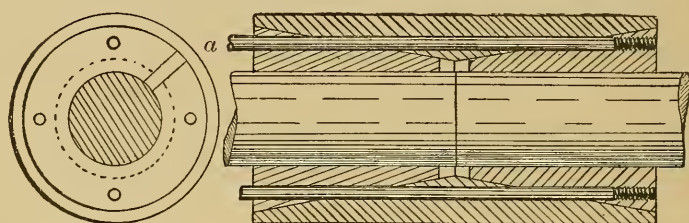


FIG. 97.

Turn and fit to the hole in each of the cones, easy without shake, 3" in length of the piece



FIG. 98.

used as a mandrel. Fasten the cones tightly on it with the little screws and true off and finish the outside of the ring or shell.

This exercise takes in about all that the lathe is capable of doing, including facing, boring, drill-

ing and tapping, parallel and taper turning, taper and parallel fitting, finishing on a mandrel and polishing.

Such pieces as fancy posts for electrical and telegraphic work, straight-way or three-way cocks for indicator practice, etc. (Fig. 99), can be easily

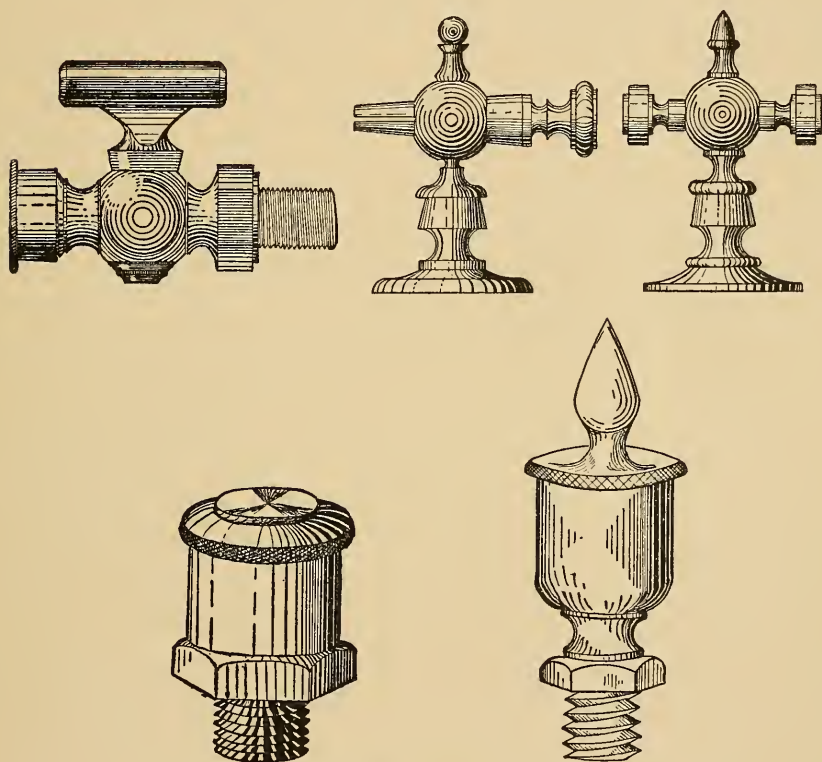


FIG. 99.

turned and finished up. They are useful exercises for practice, but do not involve any new methods of working.

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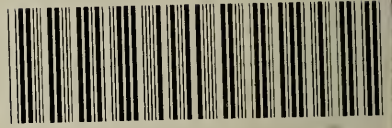
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